Synthetic Rutile Plant
Muchea

Cooljarloo Joint Venture Pty Ltd

Report and Recommendations
of the
Environmental Protection Authority

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Summary and Recommendations

This report is the result of the Environmental Protection Authority's investigations into the proposal by Cooljarloo Joint Venture Pty Ltd (formally TiO_2 Corporation) to build and operate a synthetic rutile plant next to its dry separation plant which would be sited 4 km north of Muchea.

Cooljarloo Joint Venture is proposing a four part vertically integrated mineral sands industry consisting of:

- A mine at Cooljarloo;
- A dry separation plant at Muchea;
- A synthetic rutile plant at Muchea; and
- A pigment plant at Kwinana .

The Environmental Protection Authority has already assessed the proposed mine and the dry separation plant and found them environmentally acceptable. This report is the Environmental Protection Authority's assessment of the synthetic rutile plant. Nothing in this report should be construed in any way to pre-empt the Environmental Protection Authority's assessment of the proposed pigment plant at Kwinana.

The Environmental Protection Authority requested that Cooljarloo Joint Venture prepare a Public Environmental Report (PER) which the public examined , and made comments on , to the Environmental Protection Authority.

In this report the Environmental Protection Authority examines environmental issues as they relate to this project. The water for this project is proposed to be extracted from the Gnangara Mound and piped to the site. The Authority's objective is that the environmental impacts of water extraction should be in accordance with the environmental objectives for the Gnangara Mound and that there should be no water related impacts from the plant's operation outside the plant boundary. The Authority was also concerned that the spread of dieback disease along the pipeline route be prevented during the construction of the pipeline.

Other recommendations in this report are directed to ensuring that impacts from dust , noise and air emissions from the plant are acceptable outside the plant boundary and that the potential environmental impacts of the plant are effectively monitored.

The Environmental Protection Authority considered that the PER was inadequate in that it did not contain sufficient information on which the public could determine the likely environmental impacts of this project. The Environmental Protection Authority found this unsatisfactory. Cooljarloo Joint Venture has subsequently provided the Environmental Protection Authority with additional information, however, it would have been desirable if the quality of the PER had been adequate.

After examining all the available information in the PER , and other documentation supplied by Cooljarloo Joint Venture , the Environmental Protection Authority has come to the conclusion that it is possible to build and operate a synthetic rutile plant at the proposed site in such a way that impacts on the environment are acceptable. The Environmental Protection Authority has made recommendations accordingly.

Although the scope of environmental impact assessment is limited to biophysical and some directly related social aspects of development, there is an increasing tendency for the public to raise a wide range of social, economic and quality of life issues before the EPA. The Authority does not see this report as the occasion for making recommendations about how these concerns can be addressed, but considers that this is a matter that should be further explored.

RECOMMENDATION 1

As a consequence of examining the Public Environmental Report , the additional information supplied in response to the public submissions and Environmental Protection Authority requests , and the Environmental Protection Authority's own investigations, the Environmental Protection Authority concludes that the proposed synthetic rutile plant at Muchea is environmentally acceptable.

Therefore the Environmental Protection Authority recommends that Cooljarloo Joint Venture be required to adhere to its commitments in the Public Environmental Report and in reports it has subsequently given to the Environmental Protection Authority , and the recommendations made in this report.

RECOMMENDATION 2

The Environmental Protection Authority notes that extraction of water from the Gnangara Mound by the Water Authority of WA has already been assessed by the Environmental Protection Authority. In that assessment the Environmental Protection Authority set objectives to ensure that the wetlands and the biological value of the vegetation of the Gnangara Mound be protected. To ensure that protection for this project the Environmental Protection Authority recommends that the specific techniques developed from that assessment to protect the environment , particularly with respect to wetlands and native vegetation , be applied to the groundwater extraction for this proposal. This should be to the satisfaction of the Environmental Protection Authority prior to extraction commencing .

RECOMMENDATION 3

The Environmental Protection Authority recognises the importance of preventing the introduction of the dieback fungus *Phytopthora cinnamomi* into the borefield area. Consequently the Environmental Protection Authority recommends that Cooljarloo Joint Venture be required to prepare and operate a management programme to the satisfaction of the Department of Conservation and Land Management to prevent the introduction of the dieback fungus *Phytophthora cinnamomi* into the borefield area or along the pipeline and access route.

RECOMMENDATION 4

The Environmental Protection Authority has the objective that there should be no water related impacts from the plant's operation outside the plant boundary. To ensure that this objective is achieved the Environmental Protection Authority recommends that Cooljarloo Joint Venture be required to prepare , prior to construction , and subsequently implement to the satisfaction of the Environmental Protection Authority:

- **A detailed drainage plan for the site after seeking the advice of the Swan River Management Authority;**
- **Design plans for the construction of the waste water disposal system after seeking the advice of the Water Authority of Western Australia.**

RECOMMENDATION 5

The Environmental Protection Authority considers that this plant should not be visually obtrusive. To ensure that this objective occurs the Environmental Protection Authority recommends that Cooljarloo Joint Venture be required to prepare , prior to construction , and subsequently implement a detailed landscaping and planting programme designed to:

- **Screen the plant from neighbours and roads;**

- Lower the water table on the site; and
- Improve the fringing river vegetation.

This programme should be to the satisfaction of the Environmental Protection Authority

RECOMMENDATION 6

From its investigations of other similar plants the Environmental Protection Authority is aware of the potential for dust nuisance from these plants. Therefore the Environmental Protection Authority recommends that Cooljarloo Joint Venture be required to prepare , and implement , a plan to minimise the potential for wind blown dust nuisance from its plant and the prevention of spillage of residue on to roads during transport of residue back to the mine site. This plan should be to the satisfaction of the Environmental Protection Authority.

RECOMMENDATION 7

The Environmental Protection Authority considers that noise impacts from the proposed development should be minimised during construction and operation. Matters requiring particular attention in this regard would include:

- Hours of operation , in particular the timing of any noisy procedures;
- When necessary the use of the quietest machinery available ;
- Specific conditions to ensure the minimisation of noise impacts will be set as a condition of the Environmental Protection Authority's Works Approval.

RECOMMENDATION 8

The Environmental Protection Authority recommends that the bridges crossing the Chandala Brook be designed to minimise disruption to the banks of the Brook and that the entry to the Brand Highway be designed , and contingency plans prepared , so as to contain and enable the recovery of any spill which may occur to be recovered. These plans should be to the satisfaction of the Environmental Protection Authority.

RECOMMENDATION 9

The Public Environmental Report and subsequent documents contain commitments to on-going monitoring and management of the plant. The Environmental Protection Authority recommends that Cooljarloo Joint Venture be required to submit , prior to construction , and subsequently implement , an environmental management programme relating to all aspects of environmental monitoring and management . The environmental management programme should include submission of annual and comprehensive triennial reports to the Environmental Protection Authority on the environmental monitoring and management of the project.

RECOMMENDATION 10

The Environmental Protection Authority considers that when the plant ceases operation permanently the decommissioning and site cleanup should be the responsibility of the proponent and that the State should have no responsibility for cleaning up the site. Consequently the Environmental Protection Authority recommends that the proponent be responsible for decommissioning the plant and surrounds , and that 6 months before decommissioning the proponent submit decommissioning plans to the satisfaction of the Environmental Protection Authority.

Section 2

2.1 The Role of the Environmental Protection Authority in the assessment of this project

In its assessment of this project the EPA has made sure that the impacts from Cooljarloo Joint Venture's synthetic rutile plant on the air , water , soil , flora and fauna and surrounding land use and residents are acceptable according to generally accepted environmental principles.

The EPA has only come to this conclusion after making a number of requests for more information from Cooljarloo Joint Venture. During the process of responding to public submissions Cooljarloo Joint Venture has subsequently made some significant changes to the project which have significantly reduced the potential environmental impacts of the project to the point that the EPA considers that the project is now environmentally acceptable. These changes are detailed in this report.

The EPA considers that the strength of the Environmental Impact Assessment process lies in the opportunity it provides for public participation and its ability , as in this case , to ensure the environmental acceptability of proposals. However , for this project , the EPA did not consider that there was adequate information in the PER document supplied to the public from which to gain an understanding of the likely environmental impacts of this project. Further more the public did not have the benefit of the additional information supplied to the EPA. The EPA is making this additional information available to the public. The text of the additional information on water related impacts and the summary of commitments is attached as an Appendix to this report. More technical information from these reports is available for public viewing at the EPA's head office.

Although the EPA has found this proposal environmentally acceptable the EPA does not consider that this should be construed as a statement about the acceptability or otherwise of the Muchea area for heavy industrial development.

The proposal by Cooljarloo Joint Venture to develop a mineral sand processing industry at Muchea represents further industrial development on the Swan coastal plain north of Bunbury. This is a region already under intense demand from competing land uses. This proposal has attracted a considerable amount of opposition from local residents who think that such industry would destroy the rural character of their area and represents the "thin edge of the industrial development wedge."

Although the scope of environmental impact assessment is limited to biophysical and some directly related social aspects of development, there is an increasing tendency for the public to raise a wide range of social, economic and quality of life issues before the EPA. The Authority does not see this report as the occasion for making recommendations about how these concerns can be addressed, but considers that this is a matter that should be further explored.

2.2 The Procedure for the assessment of this project

There are two mechanisms available within the Environmental Protection Act to ensure that projects such as this are environmentally acceptable. The first , under Part IV of the Act , encompasses the assessment of the impacts of proposals by the EPA through its recommendations to the Minister for the Environment. These recommendations form the basis of the conditions which the Minister applies to projects. The intent of these recommendations is to state the EPA's environmental objectives for the project and recommends means by which these objectives can be met. Most of the recommendations in this report are of this nature.

For projects of the nature of this synthetic rutile plant , the Environmental Protection Act also provides the means by which environmental conditions are imposed through Works Approval

and Licenses issued under Part V of the Act. Through this mechanism , specific technical details of the means of achieving the Ministers conditions are determined and enforced.

The assessment of environmental impacts of this project went through the following process.

The EPA asked Cooljarloo Joint Venture to prepare a Public Environmental Report (PER) which would tell the public :

- What the project was about;
- The place the plant would be located;
- The possible effects this plant would have on the environment;
- What Cooljarloo Joint Venture were going to do about these effects.

The EPA provided guidelines for the contents of the PER , these are in Appendix 5

Cooljarloo Joint Venture prepared the PER and released its document for the public and government organisations to examine and send their comments to the EPA. The comments identified areas in the PER about which more information was required , questioned the validity of the aspects of the report or provided comment on the project.

When the EPA had received all the comments it summarised them as a series of questions and gave them to Cooljarloo Joint Venture to answer.These questions and Cooljarloo Joint Venture's answers can be found in Appendix 2.

In the EPA's opinion Cooljarloo Joint Venture prepared a PER which was inadequate in the following areas:

- The PER did not contain sufficient information on which to form a detailed understanding of what would be the likely impacts of this project on the environment , particularly with respect to the process leading up to the selection of the proposed site , water extraction , use and disposal , air emissions and provisions to monitor any potential environmental impacts;
- The PER made only very generalised commitments to protect the environment. The commitments , in the main , did not make statements of the form - 'if a certain event occurs , then Cooljarloo Joint Venture will... ' or 'Cooljarloo Joint Venture will install a certain piece of equipment so that ... '. The commitments in the PER were mostly too general to be workable
- The PER relied on cross referencing to the dry processing plant ERMP for relevant information for the PER instead of providing a PER which could stand alone.

After examining the responses to its questions the EPA considered that while some of its questions had been answered there was still not sufficient information on which to determine what would be the environmental impacts of the proposed water extraction , use and disposal; and what commitments were being made to protect the environment.

The EPA then told Cooljarloo Joint Venture that before the EPA could or would prepare an assessment report Cooljarloo Joint Venture had to provide a detailed report on the water supply , use and disposal; and further commitments on the management of air and noise emissions , transport and other matters.

The additional information on water related issues was supplied in the form of a stand-alone document and is attached to this assessment report as Appendix 2. A summary of commitments made in the PER , and those later supplied by Cooljarloo Joint Venture are listed in Appendix 3.

After receiving this information the EPA considered it had sufficient information on which to make an assessment of the impacts on the environment of this project and has prepared this assessment report.

Section 3 Summary Submissions made by the Public

Forty submissions were received from the public and Government agencies. Some of the public made multiple submissions. The comments have been summarised into broad areas and are listed below.

Site Selection and Site Related Issues

These comments fell into two main categories, the acceptability of mineral processing industry in the Muchea area, and the suitability of the site for an industrial development. Comments are summarised below:

- The site is too close to Muchea and residents.
- Environmental factors were not considered in site selection.
- The PER did not demonstrate any thorough investigation of alternative sites other than in the Muchea area.
- The industry will degrade farmland and destroy the rural character of the area.
- The zoning of the area is not appropriate for industry.
- The site is lowlying, waterlogged and will have to be drained.
- Lights from the plant will disturb neighbours.
- The plant will jeopardise the water supply for surrounding farms.
- The site is too close to the Chandala Brook.
- The plant layout is different in the Dry Processing Plant NOI and the PER.
- This plant will destroy the lifestyle of the people living in the area and cause property values to drop.
- An overwhelming portion of the local population do not want the plant at this location.

On and Off-site Impacts on Flora and Fauna

- The PER should have considered flora and fauna impacts both on and off-site.
- What effect will lowering the water table have on the flora and fauna of Chandala Brook?
- Chandala Brook feeds the Ellen Brook which, downstream, supports the Western Swamp Tortoise. Will this project have any impact on Ellen Brook or the Western Swamp Tortoise?
- Lake Chandala Nature Reserve is an important refuge for the strawnecked-ibis, will this plant effect that Reserve?
- What effect will the abstraction of water for the plant have on the flora and fauna.
- Are there any rare or endangered species of flora or fauna on-site.

Air Emissions

The comments on air emissions were concerned mainly with the likely atmospheric conditions prevailing at the site and the accuracy or otherwise of the information provided in the PER. Comments are summarised below:

- The atmospheric data used in the PER comes from Pearce, this data is inadequate for modelling in the Muchea area.

- There are a far greater number of inversions during winter in the Muchea area than at Pearce.
- The proposed controls of sulphur dioxide and hydrogen sulphide are inadequate.
- There is a considerable amount of sulphur being released to the atmosphere,
- Will this cause acid rain or increase acidification of surrounding lands which already require liming?
- Rainfall is used by farmers for drinking water in surrounding areas.What effect will the plant have on the rainfall?
- What will be the effect of emergency venting of air emission on the surrounding area?

Water Abstraction, Process Water and Water Disposal

The section on water related issues received the most criticism of all sections in the PER. Comments focused upon the lack of information about the effects of water abstraction, the paucity of information about process liqueurs and process design, the inadequacy of information on water disposal design and the lack of information on which to make an estimation of likely impacts on ground and surface waters and the Chandala Brook. Comments are summarised below:

- What is the exact location of the abstraction bores?
- What effects will result from the abstraction of the water?
- How much water will be used by the synthetic rutile and dry process plants?
- The Water Authority have reduced licences for groundwater extraction in this area. How then can this plant use such large quantities of water?
- What route will the pipeline take to the plant?

Site considerations

- The site is lowlying and drains directly to the Chandala Brook, what effect will this plant have on the nearby watercourses?
- How will the site be drained?
- What type of soil is found on the site?
- Is there sufficient material from which to construct the various ponds?
- What is the level of the water table across the site?

Process Liquid

The following matters were not addressed in regard to wastewater.

- What does the waste water contain?
- Can it be recycled?
- Can it be returned to the ground?
- What will be the effect of leakage from the plant?

Process Liquid Disposal

- Liquid wastes should not be discharged to the Chandala Brook System.

Pipelines

- What provisions have been made to cope with a pipeline rupture?

Disposal Ponds

- What will be the effect of leakage from the ponds?
- There is reasonable doubt due to the fact that the basins all lie on the Chandala Brook Floodplain that liquids in the ponds will be contained.
- The method of lining ponds was not considered. Damage to the pond lining material will immediately result in contamination of the surrounding area and groundwater.
- Claycapping the ponds at the end of the project may not be sufficient to prevent waterlogging if there is severe or repetitive flooding.
- Details of bird proofing of acid effluent ponds are needed.
- What is the capacity of the ponds to cater for all process wastes in months subject to rainfall rate well in excess of the evaporation rate?
- What will happen to the liquid in each pond when it is due for cleaning out? If all the ponds are full where will the contaminated liquid be pumed.
- The PER does not provide details of the monitoring system to be installed for leak detection during operation of the ponds.
- Instead of iron-oxide slurry passing to a storage pond where the iron oxide solid settles and ammonium chloride solution is recycled to the aerators, use of a thickener and filter for the iron-oxide may be more suitable. A thickener would dewater the iron oxide, better producing higher ammonium chloride removal.
- Frequent monitoring of the evaporation storage pond will be necessary to ensure that there is a maximum level of heavy metal deposition in the ponds by maintaining the pH around the stated value of 9.4.

Other Liquid

Effluent disposal

- The proposed sewage disposal system of septic tanks and leach drains are inadequate to prevent pollution of Chandala Brook and consequently domestic and stock water supplies.

Stormwater disposal

- There is mention of the stormwater basin overflowing into Chandala Brook, but no specific details of what this water will contain, how often overflow will occur or alternative methods of dealing with the overflow.

Site surface runoff

- Will surface runoff have any effect on the surrounding wetlands, stream etc?

Solid Waste

Comments were mainly about the use of solid wastes for a soil conditioner.

- There is concern that dried solids will not be safe for use as soil conditioners.
- There should be early implementation of a research program to establish how the

solid wastes can be used as soil conditioners so that their disposal can be put to a beneficial result.

- Results of studies on the use of solid residues should be examined before the use proceeds.
- No details have been provided regarding the possible use of iron oxide in a land regeneration program.
- The PER mentions that iron oxide residues will contain Th232 and that this will be returned to the minesite for burial but there is no indication of the effect of this on the environment.

Radiation

- Some submissions did not accept that there are 'safe limits' for increases in radiation.
- Long term studies have shown that low levels of radiation are statistically linked to increased cancer rates.
- The risk from radiation is cumulative and workers and people living close to concentrated radiation sources have a higher risk of developing cancer than has been previously calculated.
- The British Radiological Board has suggested lower annual exposure limits for radiation than given in Appendix 5 of the PER.
- The radiation monitoring program is essentially the same as that for the Dry Process Plant. If the program principles are followed, the standards will be met.
- The view was expressed that the radiation levels are extremely low and should be controllable.
- No consideration has been given to radioactive contamination of the plant. There should be specific monitoring details, remedial action to reduce build-up and details of resulting waste disposal.
- Items susceptible to surface contamination pipes, pumps, tanks etc, should not be allowed off-site unless examined for radioactive contamination.
- Details should be provided about where the radioactive elements end up in the process. The proponent should provide a complete analysis of the waste streams to identify the destination of radium and its daughters.

Traffic

- There is concern that the Company may use the Old Gingin Road for access to the plant. As this represents a massive increase in traffic on this gravel road, it would be a major impact. Residents on Old Gingin Road do not want traffic associated with the plant to use the road.
- At the exit and entry points to the Brand Highway, the roads should be widened, signposted and provision made so that there can be clear visibility in both directions.
- The high accident record of the Brand Highway will be increased because of the increased volume of traffic represented by the proposal.
- The PER has not mentioned accident scenarios in terms of transport.

Transport of materials

- As the Midland rail line is adjacent to the processing site and the proponent intends to

construct a spur line into the plant for transport of bulk products to Kwinana, coal could also be transported by rail from Collie to the plant instead of by road.

- The acid should be brought in by rail to minimise the risk of spillage.

Other

- The presence of coal dust is not mentioned in the section on dust emissions, nor are procedures to minimise such dust.
- If the Old Gingin Road is used for access to the plant, the traffic noise will disturb residents on this road.
- The plant is likely to cause noise pollution which could affect the health of nearby residents.
- Synthetic rutile plants in other areas are major air polluters.
- Details of Aboriginal sites should have been included in the PER. What would happen if important Aboriginal sites are discovered within the planned plant site?
- The PER has not mentioned accident scenarios on-site, or the possible effects of the combinations of large amounts of different chemicals (lime, sulphuric acid, ammonium chloride, sulphur).
- Details about alternative technologies is not provided in the PER and therefore there is not enough information to determine whether the Improved Becher process is the most acceptable.
- Kerr McGee's industrial safety record in the USA should be examined.
- The PER is superficial and lacking in important technical details.
- The synthetic rutile plant and dry processing plant should be assessed together as the projects are using the same buildings, ponds, machinery etc.

Section 4 Cooljarloo Joint Venture's Proposal

Cooljarloo Joint Venture are proposing to have two plants on the site at Muchea. These are:

- A dry separation plant to separate ilmenite , rutile , leucoxene , zircon , monazite etc from mineral sands;
- A synthetic rutile plant to convert ilmenite from the dry separation plant into synthetic rutile.

The dry separation plant has been assessed by the EPA. Its assessment report is available to the public , EPA Bulletin 344.

In its assessment of the synthetic rutile plant the EPA has considered the combined impacts of both plants. The recommendations made for the synthetic rutile plant have been made taking into account those made for the dry separation plant.

The purpose of the synthetic rutile plant is to convert ilmenite into a mineral closely resembling natural rutile. Rutile , titanium dioxide (chemical formula TiO_2) is used to make pigment in paint , plastic etc; and to make titanium metal.

Ilmenite is a combination of titanium dioxide and iron oxide ($TiO_2.Fe_2O_3$) locked together in a mineral structure. The synthetic rutile process involves

- Roasting the ilmenite in low oxygen (reducing) conditions. This alters the mineral structure and converts the iron oxide in the mineral to iron metal;
- Converting the iron metal , which is now no longer locked in the mineral , into iron oxide and using a process similar to rusting (oxidation) ;
- Removing the iron oxide from the mineral grains (synthetic rutile);
- Treating the synthetic rutile grains with acid to remove any traces of iron which remain in their mineral structure ;

Drying the synthetic rutile (TiO_2) product.

This process can be seen in Figure 1. Each part of the process is described in greater detail below and the possible impacts on the environment associated with each section are described. How each of these impacts will be controlled is discussed in Section 6.

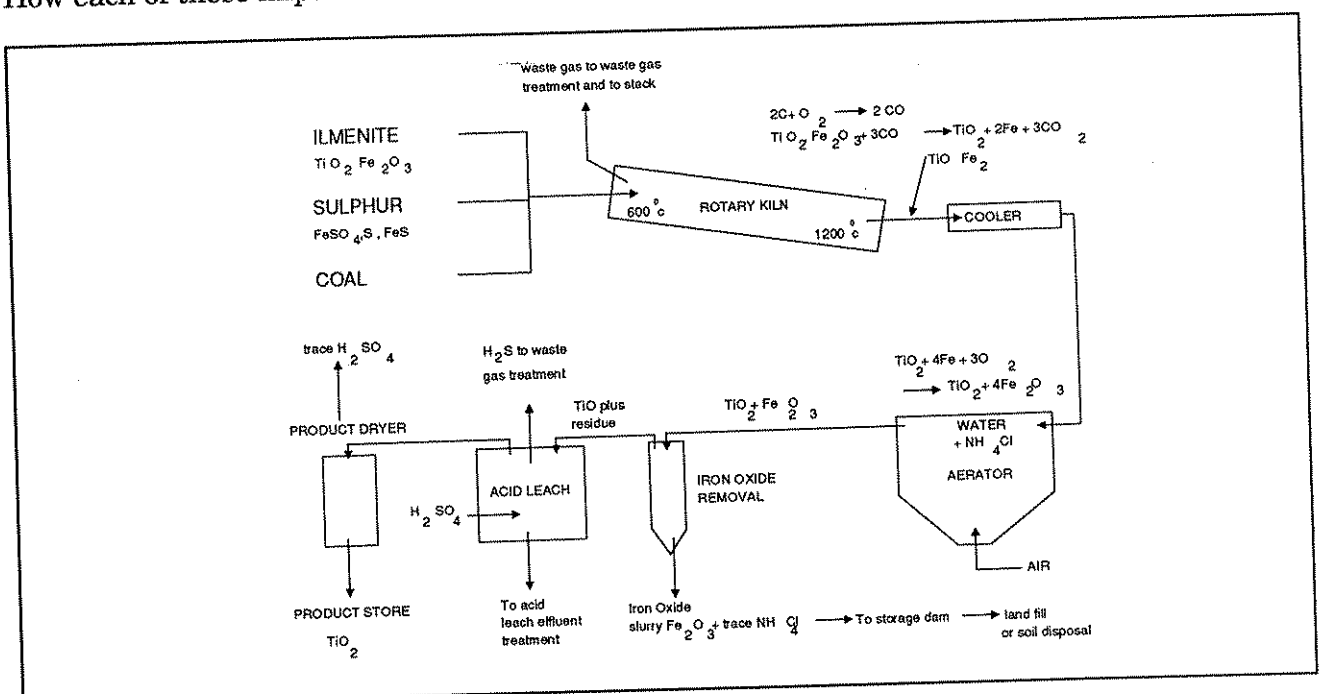


Figure 1. Synthetic Rutile Production

4.1 Raw Material Supply

The raw materials to be used are summarised in Table 1 below

Table 1 Raw Materials

Material	Use	Amount/year (tonnes)	Transport road movements/day (Section 6.8)
Ilmenite	raw material for the process	220,000	from separation plant
Coal	fuel for the kiln	100,000	20.0
Sulphur Source	added to kiln to remove oxygen	2,000	0.6
Lime	neutralises process acid	6,000	0.9
Sulphuric Acid	removes residual iron from mineral	7,000	1.1
Ammonium Chloride	helps convert iron to iron oxide	600	0.1
			Total 22.7

The ilmenite will be supplied on site from the dry separation plant. Coal will be trucked from Collie to Muchea. The sulphur source and other raw materials will be trucked from Perth. The impact of the transport of these materials is discussed in Section 6.8

It is proposed to use up to 2700 kl/day of water in the process. This is approximately equivalent to 1 000 000 kl/year. This , in terms of water use , is roughly equivalent to the water used on 5 ha of market gardens. It is proposed to extract this water from the eastern side of the Gnangara mound. The environmental impacts of this water extraction are discussed in Section 6.2.

4.2 The Process

The ilmenite , coal and sulphur are put into a long rotating kiln.

The oxygen level in the kiln is kept low by reducing the amount of air entering the kiln and burning sulphur to collect surplus oxygen. The simplified chemical reactions are as follows

$C + O_2 \rightarrow CO$

coal + oxygen→ carbon monoxide

$TiO_2.Fe_2O_3 + CO + S \rightarrow$

ilmenite + carbon monoxide + sulphur→

$\rightarrow TiO_2.Fe + CO_2 + SO_2$ + ash/dust

→reduced ilmenite + carbon dioxide + sulphur dioxide

At the exit of the kiln the reduced ilmenite is cooled and passed to the next stage of the process. The gases and ash/dust go to the air pollution control equipment [Section 6.4]

Once the product has been cooled it is slurried with water and placed into large tanks and aerated. The water contains a small amount of ammonium chloride (1%) which acts as a catalyst to speed the oxidation process which converts the iron in the reduced ilmenite into iron oxide.

$TiO_2.Fe + O_2 \rightarrow TiO_2 + Fe_2O_3$

reduced ilmenite + oxygen → synthetic rutile + iron oxide

Following the oxidation stage the product is treated to remove the iron oxide from the mineral. The product then goes to the next stage in the process. The water and iron oxide residue is sent to a settling dam where the water is removed , and sent back to the process for reuse. When the pond is full a second pond is brought into operation. The settled residue in the first pond is removed and disposed of. The disposal of this residue is discussed in Section 6.5.

The product is then treated with sulphuric acid to remove (leach) the residual iron and traces of other different metals from the mineral. During this process hydrogen sulphide and other gasses are produced. These are collected and passed to the air pollution control equipment for treatment [Section 6.4].

Following acid leaching the product is dried and stored for later transport to markets.

4.3 Major Alterations to the Project since the PER

Since the preparation of the PER, Cooljarloo Joint Venture has made a considerable number of changes to the process. These changes are in response to public concerns and to minimise the environmental impacts of the plant.

The major changes are listed in the Table 2.

Table 2. Alterations to the Project since the PER

PER	Current Proposal
Water supply not finalised	Water to be taken from the Gnangara Mound with provisions to protect the environment.
Pipeline route undetermined	Pipeline route being identified with provisions to prevent the spread of dieback.
Plant and site layout shows ponds in centre and west of property	Less ponds to be used and ponds moved to the west, away from Chandala Brook.
Site drainage uncertain	Site now planned for drainage and flood protection.
Pond design uncertain, only broad description of liners and monitoring	More details on pond design including: • locating above water table • ability to withstand storm events • underpond drainage and leak monitoring recovery • design takes account of need for availability of emergency ponds
Control of process spills uncertainAcid holding pond a possible danger to bird life	Bunding and hard standing in plant with collection drains, monitoring and recovery
Acid holding pond a possible danger to bird life	Acid holding pond removed and replaced with an in-plant tank and neutralisation
Design criteria unknown	Worst case design criteria employed
Air emissions would be controlled using an electrostatic precipitator on the main stack and a baghouse on the product drying unit	Electrostatic prepcipitator now being replaced by scrubbers to remove particulates and sulphur dioxide. Baghouse is replaced with a scrubber for better particulate removal
No contingency plans for emergencies	Contingency plans being prepared

Section 5 Site Description

The proposed site of 340 ha is approximately 4 km north of Muchea between the Brand Highway and the Old Gingin Road , see Figure 2. It slopes slightly to the west - south west. The soils are mainly sands and clayey silts. The Chandala Brook enters the property on the north western corner and flows south leaving the property in the south western corner. Three tributaries enter the Chandala Brook on the property , one from the east and the others from the west. Chandala Brook is a tributary of Ellen Brook which feeds into the Swan River. The site is low lying and parts are inundated in winter. Surface and near surface drainage is towards the Chandala Brook.

The approximately 80% of the site is cleared and has been used for grazing. The remainder of the site in the northern-centre is marginally higher than the rest and is covered with banksia woodland interspersed with marri and jarrah. It is proposed to build the plant in this area. There are flooded gum and paperbark trees along the Chandala Brook.

There are two areas of significance for the preservation of wildlife within reasonably close proximity of the plant site. These are the Chandala Brook Nature Reserve , approximately 3 km up stream along the Chandala Brook and the Twin Swamps Nature Reserve approximately 13 km south.

A more complete description of the site can be found in Appendix 2.

This project is being located into a rural area. There are no comparable sized industries in the area. The surrounding land uses are predominantly agricultural , including grazing of sheep and cattle , orchards and growing pasture and crops. There are three residences within 2 km of the plant site.

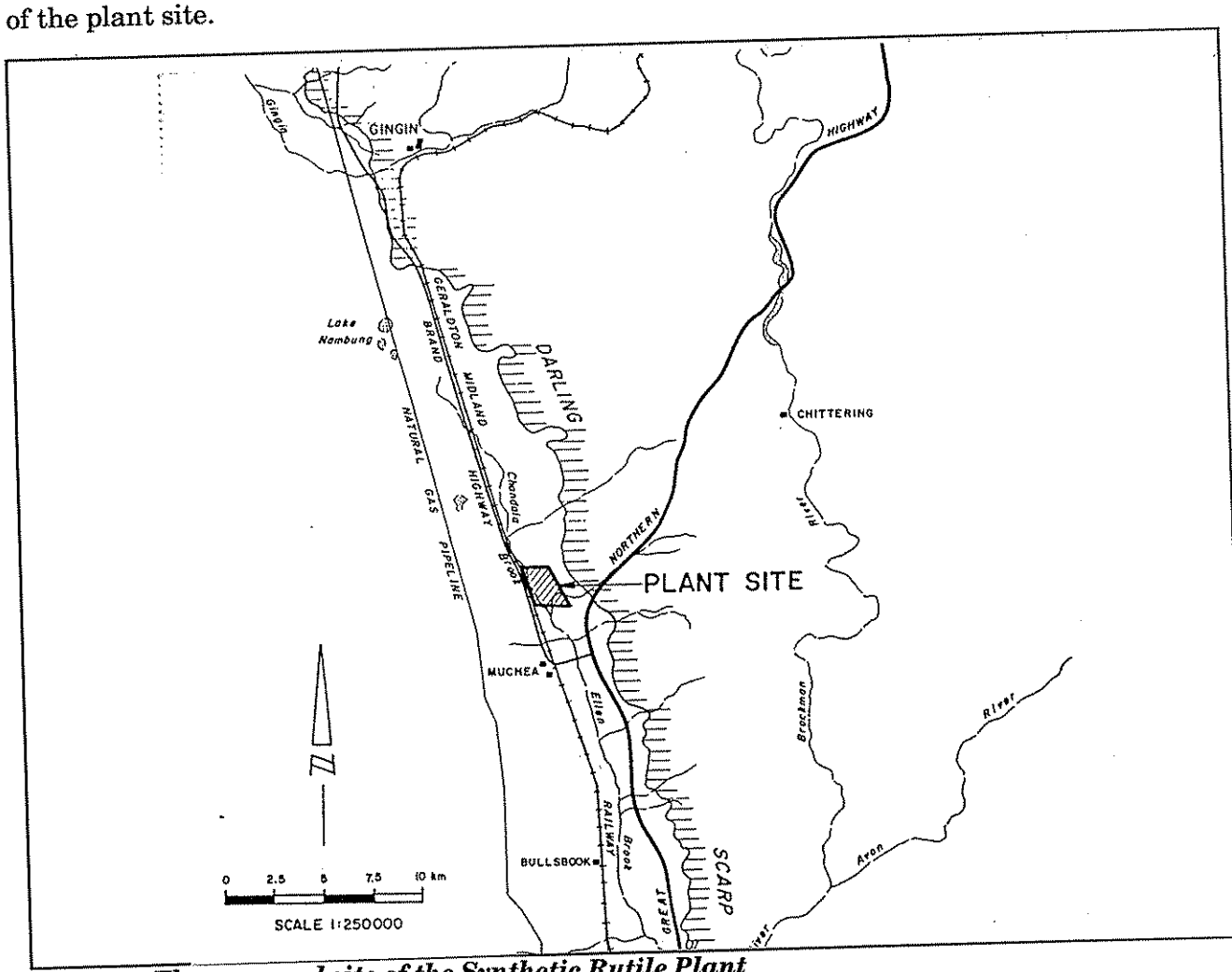


Figure 2. The proposed site of the Synthetic Rutile Plant

Section 6 Impacts on the Environment

6.1 Location and Site

Location

From the information supplied in the PER the site was favoured by Cooljarloo Joint Venture because it is close to infrastructure eg. road and rail transport , a labour market , an energy source and water and is within traveling distance of a labour market. It appears that the environmental suitability of the Muchea area for a synthetic rutile plant was not a major criteria used by Cooljarloo Joint Venture in site selection.

The alternative sites considered in the PER were , at the best , an attempt to reduce localised impacts from the plant. Neither the PER nor the cross reference to the dry process plant Environmental Review and Management Programme demonstrated to the public that environmental considerations of alternative locations outside the Muchea area had any real part in the site selection process.

The community dissatisfaction with this approach which was communicated to the EPA in the public comments.

After examining the site and investigating other similar synthetic rutile plants around Western Australia the EPA is of the opinion that:

- There are similar plants which are operating successfully in this State at locations which have less sensitivity to environmental disruption and have produced less impact while locating into the surrounding community. There is still room for projects such as this at these alternative sites;
- To successfully locate at the Muchea site major engineering will be needed to make the environmental impacts from the plant acceptable;
- Cooljarloo Joint Venture will have to operate at a very high level of proficiency through out the life of the plant to ensure the emissions from the plant do not have a detrimental impact on the surrounding area as the plant ages.

As indicated in Section 2 the EPA required that Cooljarloo Joint Venture provide additional information and commitments to that supplied in the PER. After examining this information:

RECOMMENDATION 1

As a consequence of examining the Public Environmental Report , the additional information supplied in response to the public submissions and Environmental Protection Authority requests , and the Environmental Protection Authority's own investigations, the Environmental Protection Authority concludes that the proposed synthetic rutile plant at Muchea is environmentally acceptable.

Therefore the Environmental Protection Authority recommends that Cooljarloo Joint Venture be required to adhere to its commitments in the Public Environmental Report and in reports it has subsequently given to the Environmental Protection Authority , and the recommendations made in this report.

Although the EPA has found this project environmentally acceptable it is of the view that any further proposals for industrial plants at this location will require substantial documentation prior to any consideration by the EPA. The approval of the synthetic rutile plant should not be taken as a precedent for additional developments. Rather the EPA considers that the above recommendation is a recognition that it is possible , by careful engineering , to operate this kind of plant on this site.

Site

The site layout has changed considerably from that shown in the PER , the most recent site plan is show in Figure 3. The position of the plant on the site is virtually unaltered however the locations of the various ponds has changed. The alterations to the plant layout have occurred mainly in response to environmental management requirements and changes in process design.

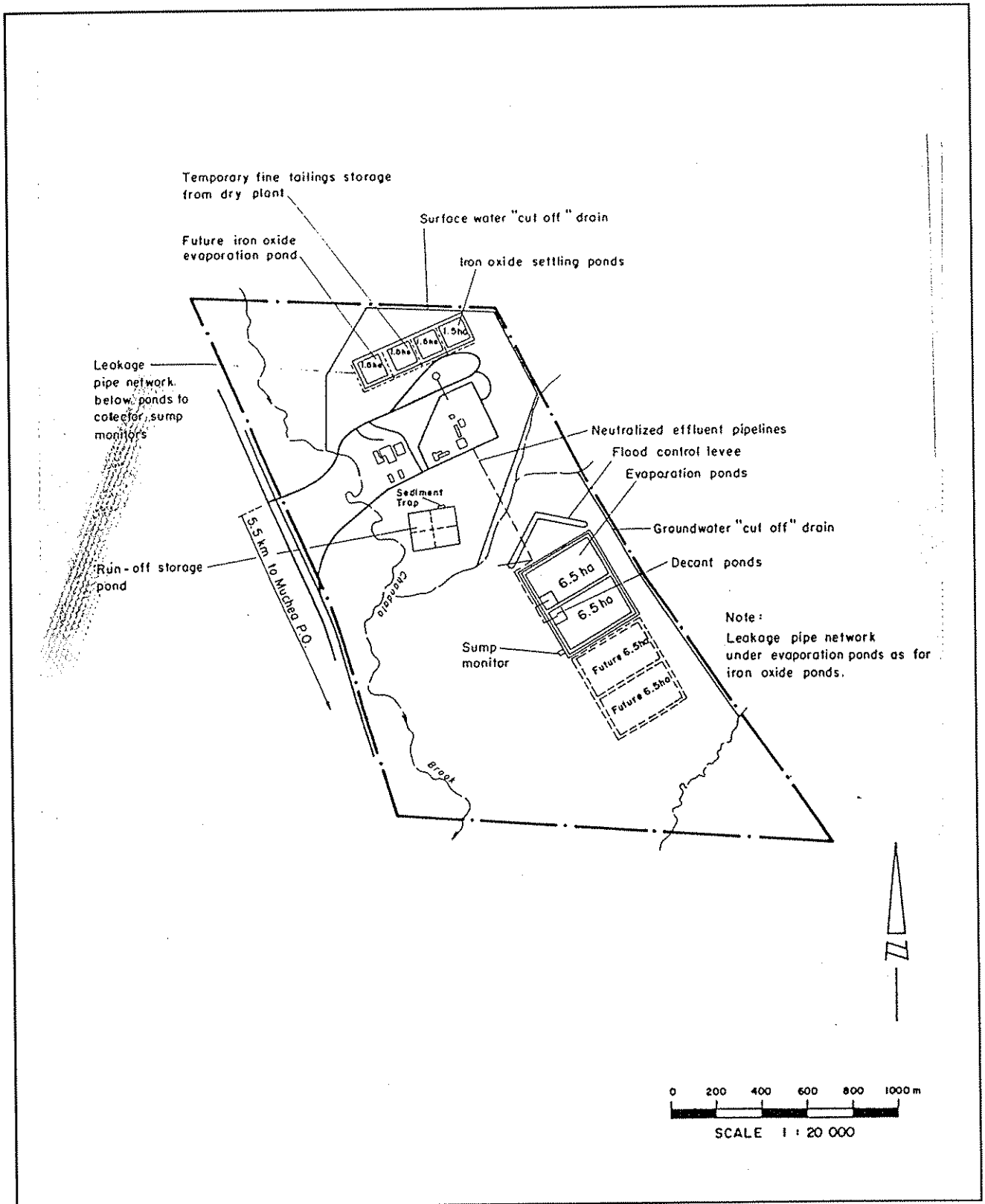


Figure 3. The Proposed Plant Layout

6.2 Water Related Issues

In addition to the advice in the PER on water related issues Cooljarloo Joint Venture provided further information in the form of a stand alone document which can be seen in Appendix 2. The information in these two documents was considered in this assessment.

There are two major potential water related impacts on the environment. These are , the effects of extracting the water for the plant , and the impacts of the plant on the ground and surface water around the plant.

In its assessment of this section of the project the EPA had the objectives that the impacts on the environment from the extraction of water should be acceptable ; and around the site there should be no water related off site impacts resulting from the plant's operations.

Water Supply

Subsequent to the advice given in the PER Cooljarloo Joint Venture are now proposing to draw water for both the dry separation and synthetic rutile plants from the near surface waters on the eastern edge of the Gnangara Mound , approximately 3.5 km west from the plant site. Cooljarloo Joint Venture are proposing to use two bores approximately 1 km apart , see Figure 4. The total amount of water now required for both plants is estimated at 2700 kl/day.

Concern was expressed in the public submissions that this project could draw water from the aquifer below the site which would effect other surrounding users. Because Cooljarloo Joint Venture are now proposing to extract all its water from the Gnangara Mound there will be no impacts from water extraction on the land uses around the plant.

Cooljarloo Joint Venture have applied to the Water Authority of WA for a licence to extract this amount of water. Cooljarloo Joint Venture are currently constructing exploratory bores in the area in order to demonstrate the acceptability of the proposal to draw groundwater from the Gnangara Mound and to determine the likely environmental impacts which would arise from the extraction of water.

In the case of the Gnangara Mound the Water Authority has prepared an Environmental Review and Management Programme which sets out the management objectives and strategies for this water resource. The EPA has assessed this document and made recommendations.

RECOMMENDATION 2

The Environmental Protection Authority notes that extraction of water from the Gnangara Mound by the Water Authority of WA has already been assessed by the Environmental Protection Authority. In that assessment the Environmental Protection Authority set objectives to ensure that the wetlands and the biological value of the vegetation of the Gnangara Mound be protected. To ensure that protection for this project the Environmental Protection Authority recommends that the specific techniques developed from that assessment to protect the environment , particularly with respect to wetlands and native vegetation , be applied to the groundwater extraction for this proposal. This should be done to the satisfaction of the Environmental Protection Authority prior to extraction commencing .

Cooljarloo Joint Venture has provided the EPA with a biological survey of the borefield area. This survey shows that the area in which the bores are proposed to be developed is highly susceptible to the dieback disease caused by the fungus *Phytophthora cinnamomi.*

RECOMMENDATION 3

The Environmental Protection Authority recognises the importance of preventing the introduction of the dieback fungus *Phytopthora cinnamomi* into the borefield

area. Consequently the Environmental Protection Authority recommends that Cooljarloo Joint Venture be required to prepare and operate a management programme to the satisfaction of the Department of Conservation and Land Management to prevent the introduction of the dieback fungus Phytophthora cinnamomi into the borefield area or along the pipeline and access route.

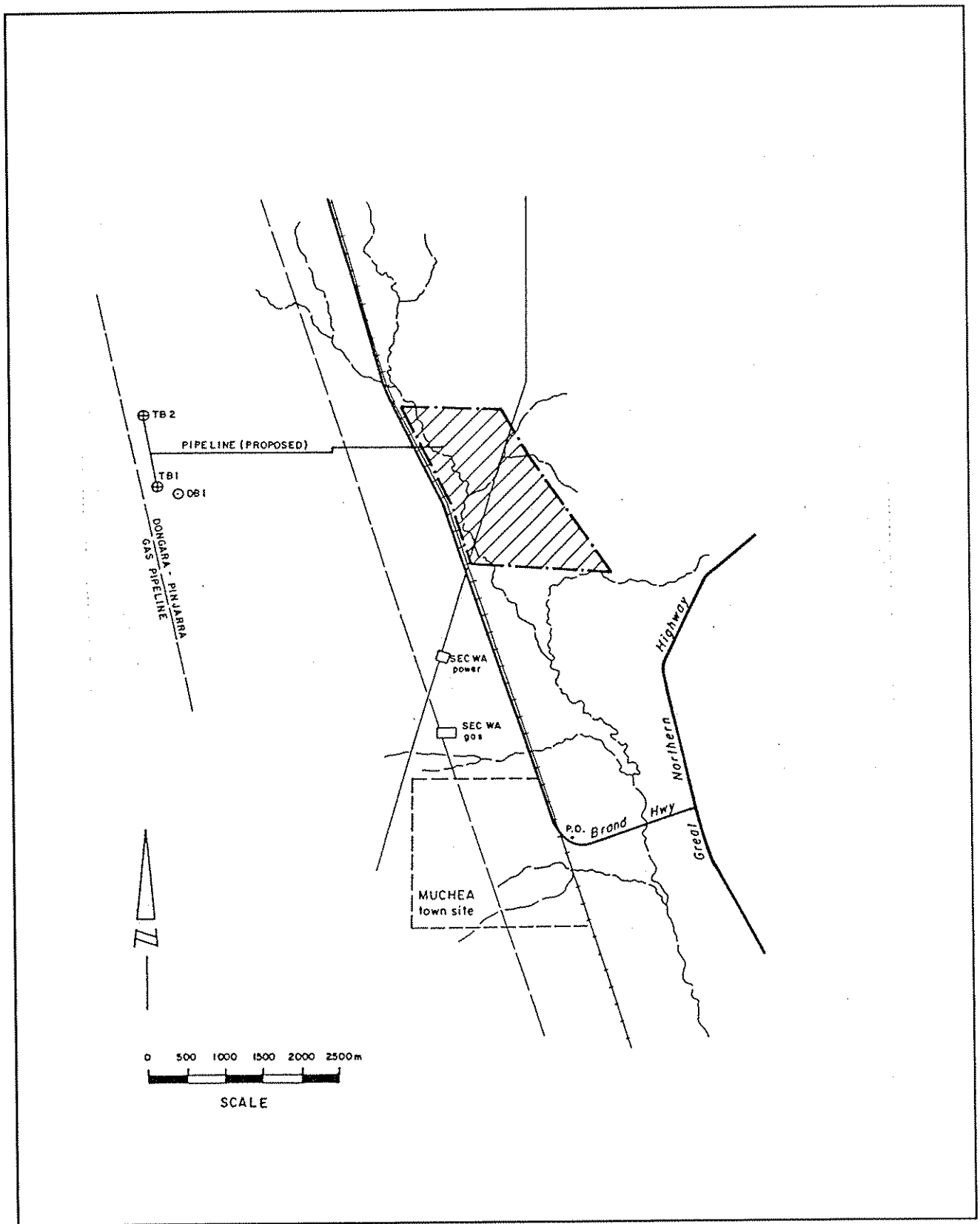


Figure 4. The Proposed Bore Field

Surface and Groundwater on the Site

Many public submissions expressed concern at the low lying nature of the property and problems with operating a synthetic rutile plant on a site which has water lying on it during winter. Submissions also expressed concern with the possibility of the contamination of the Chandala Brook from the operation of the plant. As stated in the introduction to this section the EPA has the objective that there should be no off site impacts on water from the plants operation.

In the report on the surface and ground water hydrology of the site contained in Appendix 2 the effect of a major release of process liquors (such as the catastrophic failure of a pond during winter with large surface water flows) on the ground and surface waters is assessed. The broad conclusion reached in that report is that the material from the pond would enter the Chandala Brook via the cut off drain. However by the time the pollutants reached the Chandala Brook most of the contaminants in the polluted water would be below the maximum concentrations for the maintenance of aquatic life as defined in the EPA's Water Quality Criteria for Marine and Estuarine Waters. The investigations have shown that the ground water flows are be much slower than surface water which would allow for recovery of contaminated groundwater from the near surface aquifer. Consequently the major danger to the environmental quality of the Chandala Brook resulting from catastrophic failure of a dam would be from surface , rather than ground water flow.

However it is highly improbable that there will ever be a catastrophic release from a pond and far more probable that small scale leaks from ponds or of process liquors will constitute the only potential pollution from this plant. Therefore Cooljarloo Joint Venture have proposed to separate its plant from ground and surface water by the following means

- constructing the plant on the high ground on the site;
- surface water cutoff drains to intercept surface water flows;
- raising of the various ponds above the winter water table;
- using a stormwater pond to collect all surface runoff from the plant;
- planting parts of the site with vegetation to lower the water table and reduce surface flow;
- monitoring programmes and equipment to detect and recover any leaks or spillage from the plant;
- using a levee around the evaporation pond to intercept pond over flow or leakage ;
- bunding the plant process equipment to contain process liquors in the event of equipment failure , wash down , maintenance etc;
- designing ponds to minimise the possibility of leakage and installing underpond monitoring and recovery drainage pipes.

Cooljarloo Joint Venture has provided information on pond design and other related matters in Appendix 2. This information is in response to the questions raised in the public submissions about pond design and construction , process water streams and process water content.

However the EPA considers that the detailed design of site drainage and waste water disposal should be further assessed before construction of the plant begins. Details which should be addressed include;

- location and construction details of the ponds
- details of liner , method of joining and under pond drainage and sealing;
- method of liner protection in ponds where recovery of solids is planned

- location of monitoring bores and provision for their use as recovery bores
- capacity and demonstration of adequacy to ensure no overflow of the ponds

Consequently the following recommendation is made

RECOMMENDATION 4

The Environmental Protection Authority has the objective that there should be no water related impacts from the plant's operation outside the plant boundary. To ensure that this objective is achieved the Environmental Protection Authority recommends that Cooljarloo Joint Venture be required to prepare , prior to construction , and subsequently implement to the satisfaction of the Environmental Protection Authority:

- **a detailed drainage plan for the site after seeking the advice of the Swan River Management Authority;**
- **design plans for the construction of the waste water disposal system after seeking the advice of the Water Authority of Western Australia.**

6.3 Effects on Flora and Fauna

Public submissions raised several concerns about the impact that this plant would have on flora and fauna. These are listed below

- the impact on the Chandala Nature Reserve and the nesting sites of the straw necked ibis
- the effect on the Chandala Brook and the down stream effects on the Western Swamp Tortoise
- the destruction of vegetation on the site
- water birds landing on the ponds

The EPA considers that the plant site is sufficiently removed from the Chandala Brook Nature Reserve to have a negligible impact on the Nature Reserve. If Cooljarloo Joint Venture achieves the EPA's objective , stated in Section 6.2 , that around the site there should be no water-related off-site impacts resulting from the plant's operations , there will be no impact on the Chandala Brook. The present known location of the Western Swamp Tortoise is considerably removed (10 km) from the site and the analysis of the impact of catastrophic failure outlined above shows that there would be no noticeable impact from this plant on the reserve in which the tortoise is found.

In the public submissions the acid effluent pond was identified as a potential hazard to bird life. A modification of the design of the plant has now removed the acid effluent pond thus removing this potential hazard. Following examination of similar of comparable synthetic rutile plants the EPA considers it unlikely that the other ponds , the neutralised effluent pond or the iron oxide pond would be attractive to bird life as they will contain very little vegetation or aquatic life.

With the location of the plant on the high ground on the site it will be necessary to clear a considerable amount of the banksia woodland. Cooljarloo Joint Venture now also proposes to construct ponds above the winter water table which could create some visual impact. The EPA considers that these impacts can be offset with appropriate landscaping.

RECOMMENDATION 5

The Environmental Protection Authority considers that this plant should not be visually obtrusive. To ensure that this objective occurs the Environmental Protection Authority recommends that Cooljarloo Joint Venture be required to prepare , prior to construction , and subsequently implement a detailed landscaping

and planting programme designed to:

- **screen the plant from neighbors and roads;**
- **lower the water table on the site; and**
- **improve the fringing river vegetation.**

This programme should be to the satisfaction of the Environmental Protection Authority

6.4 Air Emissions

The air emissions from the plant which are of concern are particulates , sulphur dioxide , hydrogen sulphide and other sulphur compounds. Dust from the site eg stockpiles , drying ponds , roads etc also contribute to the air emissions from the site. These are discussed below.

The particulates result from the small pieces of ash and char which get carried out of the exhaust of the kiln. The sulphur compounds come from two sources , the burning of sulphur and coal (containing sulphur) in the kiln and the hydrogen sulphide gas vented from the acid leaching section of the plant. Small quantities of sulphuric acid will be emitted from the product dryer.

Public submissions raised many concerns about the possible effects of air emissions on the surrounding land. Some possible effects of air emissions of particulates is the potential to produce black dusty residues falling out onto the surrounding area. In some situations sulphur dioxide and sulphuric acid can contribute to acidification of water supplies , damage crops and vegetation. Other sulphur compounds can produce unpleasant odors eg hydrogen sulphide smells like rotting eggs , or if at sufficient concentrations , can affect health.

From experience with other similar plants the EPA considers that the air emission most likely to be of significance in this situation is odour from hydrogen sulphide and other reduced sulphur compounds.

At the exit to the kiln Cooljarloo Joint Venture are installing an afterburner to convert the hydrogen sulphide from the acid leach section and other reduced sulphur compounds from the kiln into sulphur dioxide. This will reduce the possibility of unacceptable odours from the plant. In the place of the electrostatic precipitator described in the PER Cooljarloo Joint Venture are now planning to install scrubbers which will remove most of the particulates and sulphur dioxide emissions from the stack. The exhaust from the produce drying unit will now be cleaned by means of a wet scrubber instead of a baghouse. The result of these modifications to the design is that the overall air emissions will be better than that indicated in the PER. These changes to the treatment of air emissions resulted in changes to the water use in the plant . This has been accounted for in the calculations made in Appendix 2.

On the advice of the EPA the atmospheric modelling of air emissions was repeated. The resulting predicted maximum ground level concentrations and the distances at which they occur are listed below. The averaging times used are the same as those applied in the guidelines above.

The EPA has proposed guidelines which it considers reflects acceptable levels of fallout for various air pollutants. These guidelines do not represent standards as the circumstances in which they are applied can vary depending on location. These are listed in Table 4.

Table 3 Distances at which Maximum Ground Level Concentrations of Air Emissions Occur

Stack 1	kiln exhaust	
Particulates		25.5 $\upsilon g/m^3$ at 1111 m from the stack
SO_2		20.4 $\upsilon g/m^3$ at 1111 m from the stack
Stack 2 -	separation unit exhaust	
Particulates		231 $\upsilon g/m^3$ at 1111 m from the stack
Stack 3 -	product drying unit	
H_2SO_4		74 $\upsilon g/m^3$ at 270 m from the stack

Table 4 Guidelines for Air Emissions

Particulates	330 $\upsilon g/m^3$ for 3 min average
Sulphur Dioxide	450 $\upsilon g/m^3$ for 1 hour average
H_2SO_4	33 $\upsilon g/m^3$ for a 3 min average
Reduced Sulphur compounds eg H_2S	no noticeable odour outside the plant boundary at any time

This guide line for reduced sulphur compounds has been interpreted by the EPA to be represented by a hydrogen sulphide ground level concentration of 0.005 ppm (7 $\upsilon g/m^3$) as the detection limit for odour.

These modelling results in Table 3 indicate that the maximum ground level concentrations for all pollutants , except H_2SO_4 are below the EPA guidelines. The maximum level of H_2SO_4 occurs inside the plant boundary and falls off so that outside the plant boundary the ground level concentration is below the EPA guideline.

Based on the above figures the EPA considers that there will be an acceptable level of air emissions from the plant during normal operations. The approval for the type , reliability and efficiency of all gaseous control equipment , together with the final determination of stack heights will be a condition of Works Approval.

Cooljarloo Joint Venture have not yet provided the EPA with information on air emissions under emergency conditions. Three emergency emission scenarios identified in the PER are not infrequent (up to a few times a year). The EPA will be examining these in great detail ,

together with engineering modifications to ensure these emissions are environmentally acceptable , during setting of conditions of the Works Approval.

In summary the EPA expects Cooljarloo Joint Venture to maintain the gaseous emissions from the plant at levels which are environmentally acceptable at all times.

There is a potential for the creation of dust nuisance from stock piles , handling of materials , spillage etc. The EPA considers that these possible sources of dust can be controlled by good house-keeping. However a potential source of dust nuisance could result from the transport of iron oxide residue back to the mine site for disposal. Iron oxide residue , when wet does not represent a dust nuisance , however if it is spilled on roads and dries it is easily wind blown.

RECOMMENDATION 6

From its investigations of other similar plants the Environmental Protection Authority is aware of the potential for dust nuisance from these plants. Therefore the Environmental Protection Authority recommends that Cooljarloo Joint Venture be required to prepare , and implement , a plan to minimise the potential for wind blown dust nuisance from its plant and the prevention of spillage of residue on to roads during transport of residue back to the mine site. This plan should be to the satisfaction of the Environmental Protection Authority.

6.5 Solid Waste Disposal

The three solid wastes are generated during the process. These are

- Inert solids from the kiln such as ash , char and unreacted mineral ;
- Neutralised acid leach effluent consisting mainly of gypsum and traces of metals
- Iron oxide residue

The PER describes two methods of disposal of solid wastes. One is the transport of wastes back to the mine site , the other is to use the residue as a soil conditioner. Cooljarloo Joint Venture will be involved in studies to examine the suitability of the residue as soil conditioners. The EPA supports such investigations and considers if the use of residues as soil conditioners is found to be environmentally acceptable this represents an ideal means of solid waste disposal. The disposal of residue at the mine site should occur in an environmentally sound manner and will be reported to the EPA in the environmental management programme being prepared for the mine.

It has been the EPA's experience that the disposal of iron oxide residue has created dust and handling problems at other synthetic rutile plants. In most other plants this residue has been disposed of on company land with companies avoiding travelling on public roads as much as possible. The potential for dust nuisance during transport has been discussed above.

In the event that the use of solid residues as soil conditioners proves to be unacceptable and transport of residues back to the mine site is not possible , the EPA is concerned that an environmentally acceptable alternative is found for disposal of the residue.

6.6 Noise

In the PER discusses noise during construction and operation. The predicted noise levels during construction may , under worst case conditions , may be disruptive to neighbours. The EPA accepts that this will only happen infrequently and is therefore not considered to be of major inconvenience. Noise levels during operation must be within the levels set by the Neighborhood Noise Regulations of the Environmental Protection Act.

RECOMMENDATION 7

The Environmental Protection Authority considers that noise impacts from the proposed development should be minimised during construction and operation. Matters requiring particular attention in this regard would include:

- **hours of operation , in particular the timing of any noisy procedures;**
- **when necessary the use of the quietest machinery available ;**

Specific conditions to ensure the minimisation of noise impacts will be set as a condition of the Environmental Protection Authority's Works Approval.

6.7 Radiation

Nearly all of the radioactive minerals in mineral sands will be extracted in the dry separation plant. There will be a small carry over of radioactive mineral in the ilmenite feed stock to the synthetic rutile plant. The Environmental Protection Authority considers that the radiation monitoring programme developed for the dry separation plant will be adequate if extended to include the synthetic rutile plant.

In its assessment of the dry process plant the Authority noted that Cooljarloo Joint Venture has made a commitment to strict adherence to all Western Australian regulations and Commonwealth Codes of Practice relating to radiation protection. The EPA considers that this commitment will also be applicable to the synthetic rutile plant.

6.8 Transport of Materials

Cooljarloo Joint Venture are proposing to use rail transport to move the product to Kwinana. All other materials are to be transported by road. The EPA considers that Cooljarloo Joint Venture should examine in greater detail the possibility of using rail for the transport of other materials.

All the traffic to and from the plant will use the Brand Highway.

In the responses to public questions Cooljarloo Joint Venture recalculated that there will be an increase in traffic flow of approximately 7% through Muchea resulting from the combined operation of the dry separation and synthetic rutile plants. The EPA does not consider that this will be of major significance.

The proposed access to the site is from the west with one road bridge and one rail bridge crossing the Chandala Brook. As it is proposed to transport sulphuric acid and other raw materials by road there is a possibility that an accident at the entrance to the plant could result in a spillage of material into the Chandala Brook.

RECOMMENDATION 8

The Environmental Protection Authority recommends that the bridges crossing the Chandala Brook be designed to minimise disruption to the banks of the Brook and that the entry to the Brand Highway be designed , and contingency plans prepared , so as to contain and enable the recovery of any spill which may occur to be recovered. These plans should be to the satisfaction of the Environmental Protection Authority.

6.9 Monitoring and Management

Through out the various documents prepared by Cooljarloo Joint Venture numerous commitments have been made to the monitoring of impacts on the environmental and management of the plant and the environment in which the project is operating. These commitments can be seen in Appendix 3.

Cooljarloo Joint Venture's key commitments are:

- assessment of baseline environmental data for water and air
- monitoring of the effects on the environment of water extraction
- construction of the plant to minimise the possibility of loss of liquid contaminants to the environment
- monitoring and recovery of liquid contaminants
- monitoring and reduction of air emissions
- disposal of solid waste
- landscaping of the site

RECOMMENDATION 9

The Public Environmental Report and subsequent documents contain commitments to on going monitoring and management of the plant. The Environmental Protection Authority recommends that Cooljarloo Joint Venture be required to submit , prior to construction , and subsequently implement , an environmental management programme relating to all aspects of environmental monitoring and management . The Environmental Management Programme should include submission of annual and comprehensive triennial reports to the Environmental Protection Authority on the environmental monitoring and management of the project.

These plans should be to satisfaction of the Environmental Protection Authority.

6.9 Decommissioning

RECOMMENDATION 10

The Environmental Protection Authority considers that when the plant ceases operation permanently the decommissioning and site cleanup should be the responsibility of the proponent and that the State should have no responsibility for cleaning up the site. Consequently the Environmental Protection Authority recommends that the proponent be responsible for decommissioning the plant and surrounds , and that 6 months before decommissioning the proponent submit decommissioning plans to the satisfaction of the Environmental Protection Authority.

Section 7 Conclusion

The EPA has examined the environmental impacts of the proposed synthetic rutile plant at Muchea. The EPA considered that the PER provided by Cooljarloo Joint Venture did not contain sufficient information on which to make an adequate assessment of the environmental impacts of the project. The EPA requested that additional information on the water related impacts and upgraded commitments be supplied. After examining the additional information provided by Cooljarloo Joint Venture the EPA prepared this assessment report.

The assessment of this project has raised wider issues of public concern over the decision making process which leads up to the selection of a site for heavy industry. The EPA has commented on this matter.

The EPA is of the opinion that it is possible to construct and operate the proposed plant on this site. To minimise the environmental impacts on the site Cooljarloo Joint Venture will need to practice strict control of its process and monitoring of process emissions. The EPA considers that if Cooljarloo Joint Venture adheres to its commitments and the recommendations contained in this report the environmental impacts of this project will be acceptable.

Appendix 1

The List of questions arising from the Public Submissions

TIO2 CORPORATION NL
AND
KERR-McGEE CHEMICAL CORPORATION
JOINT VENTURE

SYNTHETIC RUTILE PLANT
AT MUCHEA

RESPONSES TO THE PUBLIC SUBMISSIONS

QUESTIONS

QUESTION 1

The proposal mentions a four part, vertically integrated mineral sands industry. What effects will occur on the proposal if one part of the proposal does not proceed?

ANSWER 1

The effect of one part in the entire mineral sands project not proceeding is detailed in Section 2.3 'No Development' Option of the PER.

Should the synthetic rutile project not proceed, the potential to add value to currently mined ilmenite will be lost.

A decision not to proceed with secondary processing will not affect the Company's decision to proceed with the Cooljarloo project involving mining of mineral sands and the construction of the dry separation plant near Muchea.

If the synthetic rutile plant does not proceed, the Company will not proceed with its proposal to develop a titanium dioxide plant as part of its strategic plan to achieve vertically integrated minerals processing capability. This would result in a substantial further loss of benefits at the local, State and National level through the loss of export revenue and introduction of new technology to Western Australia. Capital investment costs of $211m for both the synthetic rutile and the titanium dioxide plants would be lost, and in addition, annual operating costs of $76m, of which $13m is wages, would be foregone.

QUESTION 2

Is there a possibility that the TiO_2 plant proposed for Kwinana, will be relocated to Muchea?

ANSWER 2

The TiO_2 plant will not be relocated in Muchea. The various site options of the TiO_2 plant were covered in the ERMP of the Titanium Dioxide Pigment Plant at Kwinana. In summary, the Muchea site does not have a sufficient quantity or quality of water for the process, and the disposal of effluent from this site makes it economically unattractive.

QUESTION 3

There are numerous statements in the PER which indicate the proponent is doing further studies on environmental impacts and management. What happens if these studies indicate the environmental impacts of the plant will be unacceptable?

ANSWER 3

Since publishing the PER numerous studies on the site have been conducted (Vegetation, Fauna, Aboriginal) and others are still on-going (Hydrology and Radiation). The results of the completed studies have been submitted to the EPA. None of the reports has presented any insurmountable problems and none is anticipated by either of the on-going studies.

QUESTION 4

What are the site selection criteria for the synthetic rutile plant? Are they the same as those in the ERMP for the dry processing plant? Why were they not considered in the PER?

ANSWER 4

Selection of the site for the dry process plant is closely linked to the site of the synthetic rutile plant because of the benefits in capital and operating expenditures, integrated management, operations and maintenance structure which service both plants. The Cooljarloo Mineral Sands Project ERMP discussed site selection for the dry processing plant on a broader scale looking at Geraldton, Encabba, Cooljarloo and Muchea as possible site locations.

The site selection criteria are mentioned in the PER in Section 3.1.1 Selection Criteria. These criteria are the same as used for the dry processing plant when sites were considered in the Muchea area (as discussed in the Dry Processing Plant NOI).

The basic criteria for site selection are:

Economic:
- cost to develop the necessary infrastructure and supply essential services
- cost of transport of raw and finished materials to and from the site
- availability and cost of suitably designated or zoned land in the area

Social:
- availability of workforce with the necessary skills
- impact on townships and the general demography of the area
- location in area planned for industrial development

Environmental:

- suitable site where impacts of noise, air emissions, liquid and solid wastes can be accommodated
- impact of transport and vehicle movements
- aesthetic impact of the plant and facilities on the landscape

In the Muchea district, TIO2 Corporation evaluated a number of properties prior to the selection of the proposed site for the dry process and synthetic rutile plants.

QUESTION 5

Where are these sites on Figure 4.1? If all the sites are within 5km of each other, how can they have such widely differing positive features and disadvantages?

ANSWER 5

As a result of the various proposed sites being so close to each other they have many similar characteristics. The main difference between the sites is their orientation with respect to the Brand Highway, Chandala Brook and the railway line. See Figure 1 for the locations of the four sites considered in the PER.

QUESTION 6

What was the advice given when "the EPA has suggested to TIO2 Corporation that an alternative location ..."? Did the EPA indicate the acceptability or otherwise of any other site?

ANSWER 6

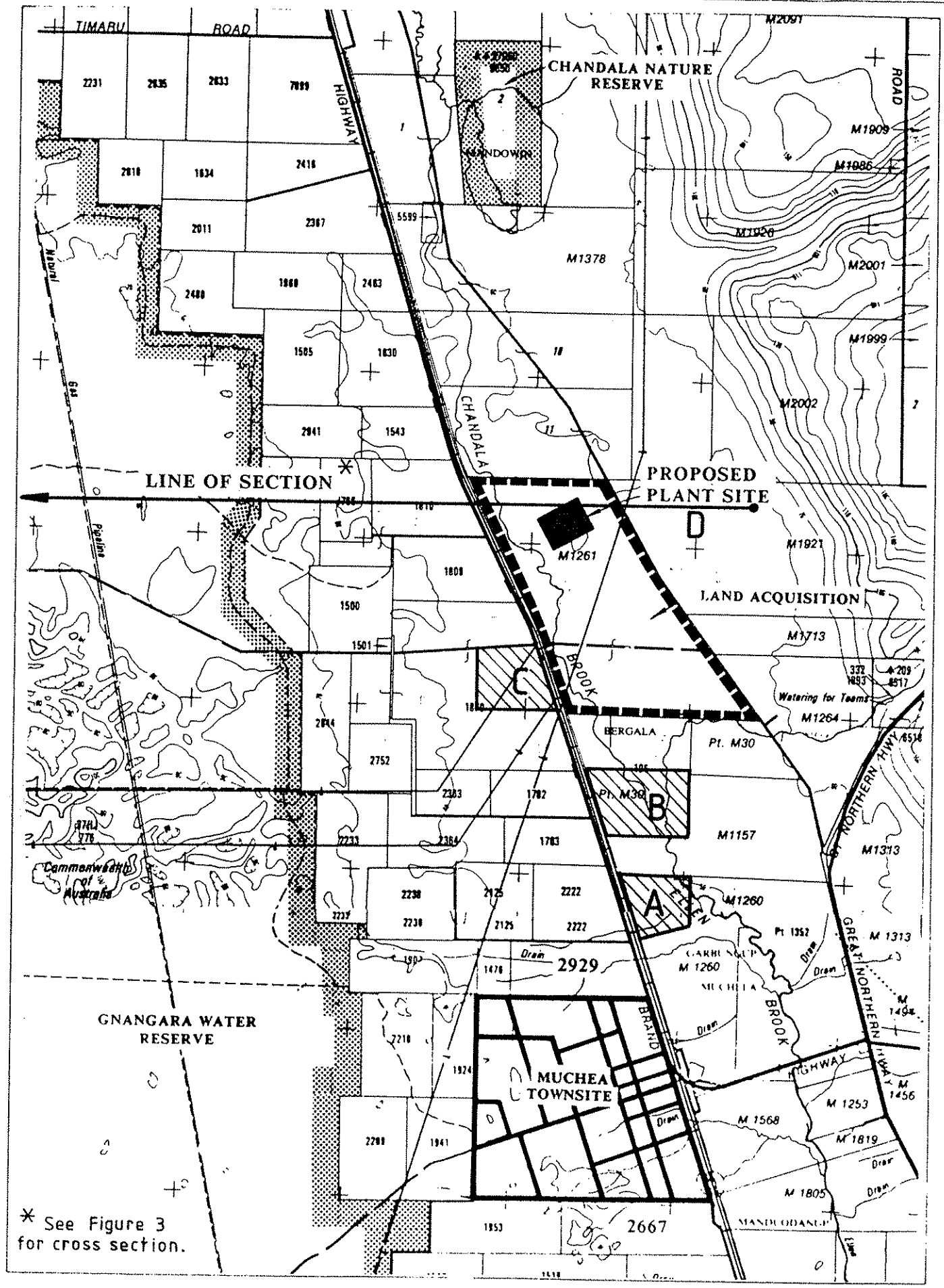
The EPA informed the proponent that there was public opposition to the original site (site A on Figure 1) located just outside the town of Muchea and suggesting that an alternative site should be seriously considered. EPA has made no comment on the suitability or otherwise of any alternative sites.

QUESTION 7

With regard to Disadvantages - Social:
Is there any comment on the survey conducted by local residents which showed that of 261 persons from within a 10km radius of Muchea, 232 do not want to see Muchea become a heavy industrial area?

ANSWER 7

Neither TIO2 nor its consultants are aware of any such survey, the conditions under which it was conducted, the area surveyed, nor the questions asked in the survey. As such, comment on the survey cannot be made.



LOCATION OF SYNTHETIC RUTILE AND DRY PROCESS PLANTS NEAR MUCHEA **FIGURE 1**

QUESTION 8

What is the current zoning of the proposed site?

ANSWER 8

The current zoning of the proposed site is rural.

QUESTION 9

Will it have to be rezoned?

ANSWER 9

Yes the proposed site will have to be rezoned.

QUESTION 10

It is assumed that the furnaces will have to be started in some manner? From where will the start up fuel originate?

ANSWER 10

There are no furnaces on site. The reduction kiln will be started up with natural gas which will be reticulated onto the site. The gas will be supplied by SECWA.

QUESTION 11

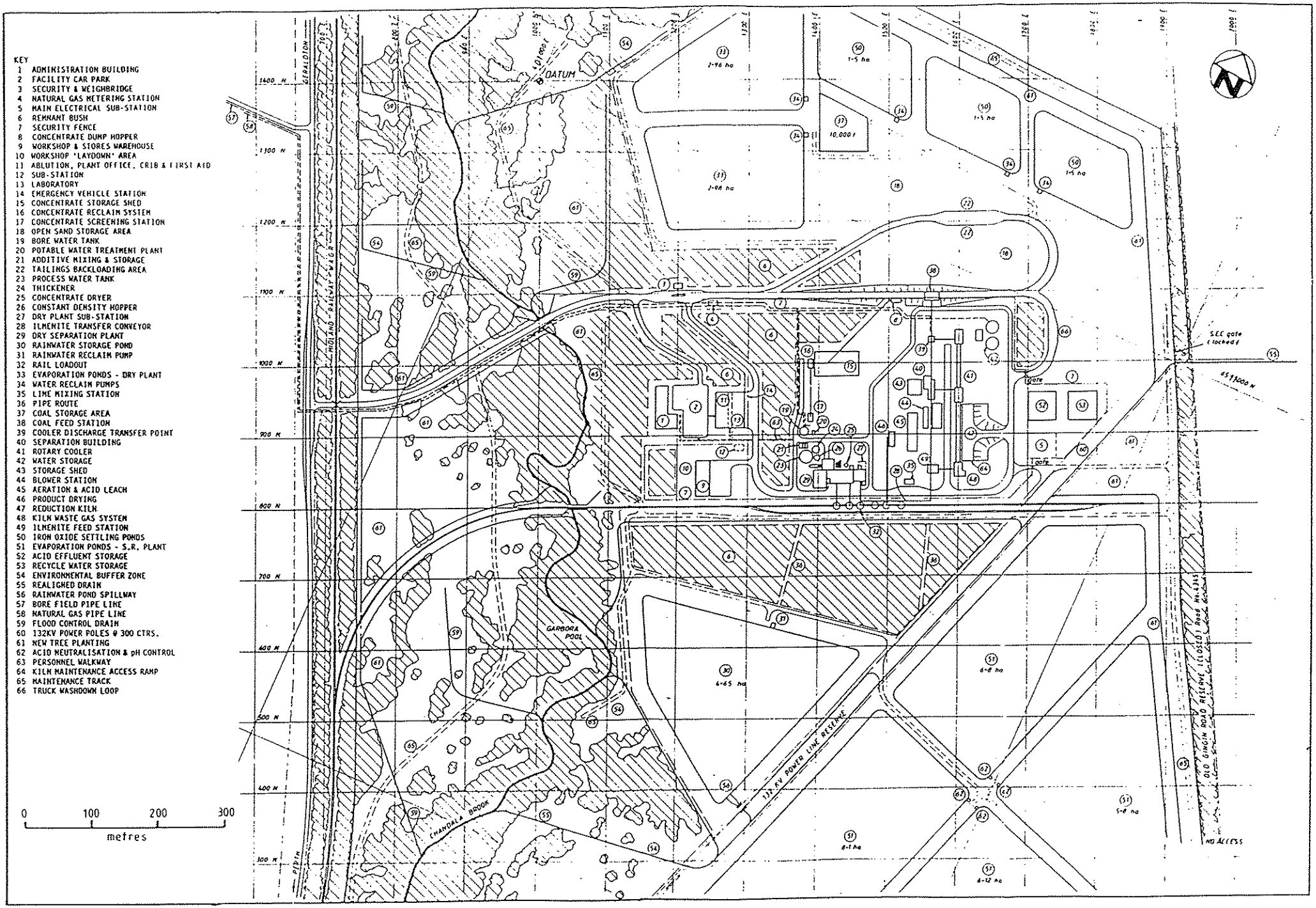
Why is this site layout different from that in the NOI for the dry plant? Are the drainage channels still proposed to be constructed?

QUESTION 12

Which site layout is an accurate representation of the plant?

ANSWERS 11 AND 12

The dry processing plant NOI includes a copy of the revised layout for the Muchea site and represents the current design concept. The drainage channels are included. See Figure 2 for the most recent site layout as presented in the NOI.



SITE PLAN AND PLANT LAYOUT FIGURE 2

QUESTION 13

Where is the lime store?

ANSWER 13

The lime store, item 35, is located near grid intersection 1500E and 800N on Figure 2.

QUESTION 14

Where are Nos 12 and 21 on the site plan?

ANSWER 14

The substation, item 12, and the additives mixing station, item 21, are part of the dry processing plant and located near grid intersection 1300E and 900N on Figure 2.

QUESTION 15

What is No 21, Additive Mixing and Storage?

ANSWER 15

The additives storage and mixing station is part of the attritioning section of the dry processing plant. The additive is a flocculant, which assists with the removal of slimes from the concentrate.

QUESTION 16

Appendix 4 gives 144.9gSO_2/sec emitted from the plant. What proportion of the sulphur burnt on-site will be released to atmosphere?

ANSWER 16

Sulphur is introduced into the process as elemental sulphur, and in coal and sulphuric acid. The sulphur leaves the process as gypsum (calcium sulphate) precipitated in the evaporation ponds and sulphur dioxide in the exhaust gas. The majority of the sulphur is discharged as calcium sulphate.

QUESTION 17

Why is an electrostic precipitator used instead of other scrubbing technology which may also remove SO_2.

ANSWER 17

Gas cleaning using wet scrubbers requires large volumes of water and produces an acidic effluent. Electrostatic precipitators are proposed in this instance effectively removing particulate emissions as SO_2 levels are within EPA limits.

QUESTION 18

Why is a settling dam used instead of a thickener and filter for the iron oxide residue? Would not this produce better ammonium chloride removal?

ANSWER 18

Filtration of the fine iron oxide precipitate is very difficult, and has proven to be unsatisfactory in practice. There is no advantage in thickening the effluent prior to discharge to the settling ponds. The ammonium chloride recovery is the same with both methods.

QUESTION 19

Will the iron oxide to be buried contain any residual ammonium chloride?

QUESTION 20

What is the chemical analysis of the iron oxide residue?

ANSWERS 19 AND 20

The iron oxide residue consists of fine particles mostly in the form of Fe_2O_3 or hematite. The liquid is a weak solution (less than 1%) of ammonium chloride. Any other elements will be at a "trace" level of concentration.

QUESTION 21

No details of dam construction or design have been given. What design is proposed? The dams should be designed to worst case scenario and not to over top under any conditions. Are they designed in this manner?

ANSWER 21

The iron oxide and evaporation ponds have not yet been designed in detail. However the design criteria call for lined ponds which will not overflow to discharge into natural watercourses. A number of ponds will be constructed suitable for the storage and recovery of settled solids. Each pond will have sufficient capacity for the design quantity of settled solids and a working volume of liquid. The design freeboard will be sufficient to cope with the rainfall from a probable maximum storm event, plus wind stress. In addition each set of ponds will be interlinked so that a full pond can overflow into a standby pond.

QUESTION 22

No details for handling procedures are given. Is there any potential for nuisance from dust?

ANSWER 22

Dry solids materials handling will generally be by closed conveying systems or covered belt conveyors. Dust producing transfer points will be protected with vacuum assisted dust collectors. Water sprays will be provided to control dust, in operations requiring the use of mobile equipment.

QUESTION 23

What are the risks and hazards associated with transporting these materials by road?

ANSWER 23

All raw materials used in the process are commonly transported by road in Western Australia. There are no abnormal risks or hazards associated with their transport.

QUESTION 24

Why isn't rail being considered as a safer option?

ANSWER 24

The quantities of process materials involved do not justify transportation by rail. Both road and rail are considered to be safe methods for transport.

QUESTION 25

Is the site part of the Chandala Brook flood plain?

ANSWER 25

The site is not a flood plain although care will be required with drainage due to the high water table. Evidence of surface water in winter across much of the pasture probably indicates the development of a hard pan, due to the fact that the pasture has not been broken up for many years.

QUESTION 26

Local residents maintain there are significant local climatic differences between Pearce and Muchea particularly with respect to height of inversions and prevailing wind directions. Are there any comments on this?

ANSWER 26

There are no specific climatic data available for Muchea. The closest source of climatic data and thus the best available data for modelling is from Pearce.

QUESTION 27

This whole section does not give the reader a clear understanding of either the surface or groundwater characteristics nor the origins or fate of the water on and below the site.

For example, what is the significance of the assertion "...Leederville Formation represents the most promising source of water supply"; and where are GD21 and GN31 relative to the site?

Please prepare a description of the Ground & Surface waters which informs the reader -

(a) what is the hydrology of the area;
(b) how the hydrology interconnects with the surrounding locality, and
(c) what are the existing water uses eg agriculture, flora and fauna etc.

Use diagrams and tables where appropriate.

ANSWER 27

Surface Water:

Natural drainage at the site is via Chandala Brook which has its course through the western part of the area to the west of the proposed plant location. Minor seasonal drain/creek flows occur from the eastern side of the site along a course which is generally to the south-west contributing to Chandala Brook downstream of Garbara Pool which is a section of deeper water in the brook.

Chandala Brook is the major surface water body nearby and all the site lies within this brook's catchment. The brook flows southwards into Ellen Brook which eventually enters the Swan River, 22km to the south of Muchea. The Chandala Brook flow is maintained by surface runoff especially from more clayey terrain, by discharges from shallow aquifers by seepages which reach the brook often via agricultural drains and natural tributaries. There are also contributions from mound springs in the head waters of some of the western tributaries and some leakage upwards from confined aquifers.

Data indicate that the salinity of Chandala Brook waters would be variable ranging between 300 to 16,000mg/L TDS with the higher salinity due to the onset of winter rains and the associated flushing of salts from the catchment.

Groundwater:

The geology of the site is known from published regional and local mapping and the logs of drillholes. The succession beneath the plant site comprises:

- Topsoil, thinly developed with patchy lateritic horizons
- Bassendean Sand, thinly represented in patches (less than 5m thick)
- Guildford Formation (30m thick) sandy clays
- Osborne Formation, predominantly sandy siltstone with shale and minor sands (120m or more thick)
- Leederville Formation, a thick sequence of sandy aquifers with interbedded siltstone and shale

Figure 3 depicts the hydrogeological section through the site and wellfield area. It must be noted however that this is based solely on a desk top study.

It is to be expected that water would be encountered in all these units, but, from a water supply viewpoint, the Leederville Formation is the most significant. This aquifer system is confined at the site beneath the Osborne and Guildford Formations which are generally poorly permeable and overall represent a barrier to vertical seepage beneath the site.

The water table at the site is shallow, commonly near ground level or within a few metres of the surface. The proposed plant location is on a patch of superficial sands, believed to contain a perched groundwater body as evidenced by minor seepages from the margins of the sand where uncleared scrub gives way to pasture grassland. This groundwater body is of limited extent and significance. The sand outcrop is not seen as evidence of deeper lying sands since it is interpreted to be overlying clays and silts of the Guildford Formation.

From a groundwater hydrology viewpoint, drainage from the site would appear to be predominantly surface runoff augmented by seepage from the margins of the sandy patch or mound. The underlying deposits separate this surficial water from the Leederville Formation by more than 100m, and there would be little prospect of groundwater flow directly from above to the Leederville Formation, or vice versa. Groundwaters flow in the Leederville Formation aquifers would be southwards beneath the site unless modified by major leakage or abstraction from the aquifers.

To the west of the site, about 3km and more away, the terrain changes from the poorly permeable or impermeable ground of Muchea that is often waterlogged in winter, to permeable sandy ground. This is an extensive area of Bassendean Sand which would be underlain by Guildford Formation in its eastern marginal area, but further west would be underlain by the Osborne Formation or even directly by the Leederville Formation. It is proposed to develop the wellfield there and to tap groundwater in the Bassendean Sand which is about 60m or more thick, 5-8km west of the plant site. The water table is about 7-12m below ground and groundwater flow potentially passes eastwards to discharge along the marginal area at the western edge of the Muchea farmlands. The recharge potential of this western region is good because the permeable sandy soils and the groundwater resources are large and extensive.

Groundwater quality is generally at salinity levels between 500 and 12,000mg/L TDS. The Bassendean Sand aquifers contain low salinity water; 90 to 200mg/L TDS may be typical of the aquifer in the proposed groundwater development area.

QUESTION 28

What is the connection between the statement "A botanical survey of the site... will be carried out prior to detailed site planning"; with Page 16 "some vegetation loss will occur" and Page 28 "plants of limited distribution occur within 6 km of the site" ie. what will happen if rare and endangered species are found on-site?

ANSWER 28

A study of the vegetation on site has been done and submitted to the EPA as part of the Dry Processing Plant, Muchea NOI. The results of this study concluded that there were no endangered species on the proposed site.

QUESTION 29

What vegetation types exist on-site?

ANSWER 29

A table of the vegetation found on site was given to the EPA in an Appendix of the NOI. See Table 1 for this table.

Species	Pastures	Periphery of Banksia Woodland	Banksia Woodland
Acacia huegelii Benth.		P	P
Acacia pulchella R.Br		P	P
Actinostrobus pyramidalis Miq.		P	
Anigozanthos humilis Lindley			P
Arctotheca calendula (L.) Levyns *	P		
Banksia attenuata R.Br		P	P
Banksia ilicifolia R.Br	P	P	
Banksia menziesii R.Br		P	P
Borya nitida Labill.			P
Bossiaea eriocarpa Bent.			P
Burchardia umbellata R.Br.			P
Calytrix ?flavescens Cunn.		P	P
Calytrix ?fraseri Cunn.			P
Cassytha glabella R.Br.		P	P
Dasypogon bromeliifolius R.Br.			P
Drosera erythrorhiza Lindley			P
Drosera sp 5		P	P
Eremaea pauciflora (Endl.) Druce			P
Eucalyptus calophylla Lindley	P	P	
Eucalyptus rudis Endl.	P		
Eucalyptus todtiana F.Muell.		P	P
Hakea prostrata R.Br.	P		
Hibbertia hypericoides (DC.) Benth.		P	P
Hibbertia subvaginata (Steudel) F.Muell.		P	P
Hypochaeris glabra L. *	P	P	P
Jacksonia floribunda Endl.			P
Jacksonia spinosa (Labill.) R.Br.		P	P
Juncus pallidus R.Br.	P		
Kennedia prostrata R.Br.		P	
Leptocarpus tenax (Labill.) R.Br.			P
Leucopogon conostephioides DC.		P	P
Lupinus sp 6 *	P		
Macrozamia reidlei (Fischer ex Gaudich.) C.Gardner		P	P
Melaleuca ?hamulosa Turcz.	P		
Melaleuca preissiana Schauer	P		
Melaleuca raphiophylla Schauer	P		
Melaleuca uncinata R.Br.		P	
Melaleuca sp 1		P	P
Melaleuca sp 2		P	P
Nuytsia floribunda (Labill.) R.Br. ex Fenzl		P	P
Patersonia occidentalis R.Br.		P	P
Pericalymma ellipticum (Endl.) Schauer		P	
Petrophile linearis R.Br.		P	P
Regelia ciliata Schauer	P	P	P
Romulea rosea (L.) Ecklon *	P		
Schoenus curvifolius (R.Br.) Benth.			P
Stylidium repens R.Br.			P
Stylidium sp 7			P
Trifolium sp 8 *	P		
Ursinia anthemoides (L.) Poiret *	P	P	P
Verticordia densiflora Lindley		P	
Xanthorrhoea preissii Endl.	P	P	P
Zantedeschia aethiopica (L.) Sprengel *	P		
Unidentified species no 9	P	P	
Unidentified grass species	P	P	P

* Species marked with an asterisk indicate naturalised plants, not native to W.A.

Appendix 1. List of Species Found on M1261 at Muchea, Western Australia during July 1988.

TABLE 1

VEGETATION FOUND ON THE MUCHEA SITE

QUESTION 30

While the site may have been used for farming for many years it also contains uncleared portions of land adjacent to the Chandala Brook. Why was "a specific assessment of fauna not considered necessary"?

ANSWER 30

A study of fauna has been conducted and presented to the EPA as part of the Dry Processing Plant, Muchea NOI. The results of this study concluded that there were no endangered species on site.

QUESTION 31

How significant is the locality for the straw-necked ibis and how will operation of the plant affect this significance?

ANSWER 31

There is no great significance of the plant locality with respect to the straw-necked ibis as they have not been nesting at the Chandala Nature Reserve since 1984 according to the Royal Australasian Ornithologists Union (RAOU). However, in the event they were to nest there again the plant would have negligible impact due to the 2km buffer zone between the plant and the reserve.

QUESTION 32

The NOI for the dry processing plant indicates the presence of archaeological sites on the banks of the Chandala Brook, where are they and are they significant?

ANSWER 32

The Aboriginal site study revealed two sites on the property. These sites were reported to the Western Australian Museum and deemed insignificant. The location of these sites cannot be disclosed to the public according to the Heritage Act. However, they have been considered in the site plan and will not be disturbed by plant activities.

QUESTION 33

Will the proponent be following the recommendations of the study commissioned to examine aboriginal sites?

ANSWER 33

Yes the recommendation to survey the site for Aboriginal sites was followed, the results of which are discussed in Answer 32.

QUESTION 34

What forms of agriculture are taking place in the area?

ANSWER 34

At present the only form of agriculture in the site is cattle and sheep grazing. In the near vicinity of the site other forms of agriculture are orchards and vineyards.

QUESTION 35

Are there any potentially negative interactions between this plant and the planes from Pearce air base?

ANSWER 35

The RAAF Base has been advised of the plant and supplied relevant information and has no objections.

QUESTION 36

The SEC has advised that the proponent will be responsible for the gas lateral crossing Chandala Brook. Is this true?

ANSWER 36

The proponent is responsible for the gas line crossing of Chandala Brook. The gas line will traverse the brook above ground on one of the two bridges.

QUESTION 37

Will there be one or two crossings of Chandala Brook?

ANSWER 37

There will be two bridge crossings of Chandala Brook as located on Figure 2. The plans for the crossing will be prepared on the advice of the Swan River Management Authority and to the satisfaction of the EPA.

QUESTION 38

Where will the bores which will supply the plant be located?

ANSWER 38

The bores to supply water to the synthetic rutile plant have not been precisely sited. It is planned that they are to tap water in the Bassendean Sand of the Gnangara Water Reserve.

QUESTION 39

What effect will be the abstraction of 2000 kl/day of water on the surrounding environment including the Gnangara Mound and the Baracca Nature Reserve?

ANSWER 39

The latest design calculations show that the dry process plant will require 685 kl/day of water. Thus, the Muchea site will now require 2385 kl/day.

The Water Authority of Western Australia ran their Gnangara Mound Model and found drawdowns of about 0.5m along the eastern margins of the Bassendean Sand terrain (to the west of Muchea).

This may be expected to produce a theoretical depletion in spring flow and seepage discharge to the seasonally water logged ground there. However, in practice it would not expect to be appreciable.

QUESTION 40

If the groundwater feeds watercourses connecting with the Chandala Brook/Ellen Brook systems, what effect will this abstraction have on these systems?

ANSWER 40

The impact of the water abstraction on the watercourses connecting with the Chandala Brook will be insignificant (see the response to Question 39 for details).

QUESTION 41

What evidence is there to substantiate that 'minimum possible declines in water levels' will occur? What local effects will this have on other water users?

ANSWER 41

The water table in the proposed borefield area is understood to be about 8m below ground in an area undeveloped for water supply. Any wetland vegetation would not be dependent upon this groundwater in the groundwater development area. Downgradient of the proposed bores, the groundwater will contribute to the springs and seeps which are a minor eastwards outflow point for groundwater in the Bassendean Sand aquifer off the Gnangara Water Reserve. The theoretical depletion in outflow is not anticipated or to be even appreciable, nor would it be expected to be detected in measurements of creek flow.

It should be appreciated that the wellfield is to be situated away from farms in an area of ground reserved for water supply. The Water Authority has been consulted on its views and preliminary verbal indications are that there would be no significant environmental or other user competition, and no significant detriment to the water resources which are undeveloped but reserved for water supply when the need arises.

QUESTION 42

Proposed subdivisions in this area have been refused because of lack of water, how then can the proponent draw, in two days, what a local farmer is allowed to use in one year?

ANSWER 42

The allocation of water is the responsibility of WAWA. TIO2 is unaware of the reasons for refusal of water for the proposed subdivisions.

QUESTION 43

Is the stormwater basin referred to in the text, No 30 in Fig 4.2?

Will the stormwater runoff be contaminated with plant fallout?

ANSWER 43

Item 30 on Figure 4.2 is the plant stormwater basin.

Incidental contaminants such as oil and dust from road vehicles will be intercepted by an oil trap constructed at the point where the drainage system discharges into the stormwater basin.

QUESTION 44

How often is it expected that the stormwater basin will discharge to Chandala Brook? Will this basin be lined?

ANSWER 44

The stormwater will be used to supplement plant raw water supplies, hence the basin would only fill on very rare occasions. The frequency is expected to be less than annual, and will be determined during detail design.

The stormwater basin will not be lined.

QUESTION 45

How much and what kind of vegetation will be cleared?

ANSWER 45

The plant will require the clearing of approximately three-quarters of the Banksia woodland.

QUESTION 46

What is the botanical value of the Chandala Nature Reserve?

ANSWER 46

As detailed in Answer 55 the Synthetic Rutile Plant will have no effect on the Chandale Nature Reserve. Therefore it is not necessary to address this question.

QUESTION 47

Are there any plants of significance on site eg Eramaea purpunea and Helopterum pyrethrym.

ANSWER 47

A list of plants found on the site is given in Table 1, none of which is of significance. The examples sited in the question, *Eramaea purpunea* and *Helopterum pyrethrya* were not found on site during the survey.

QUESTION 48

Has the vegetation assessment of the site been provided to the EPA?

ANSWER 48

Yes, the vegetation site assessment was given to the EPA in the Dry Processing Plant, Muchea NOI.

QUESTION 49

How big is "a significant buffer strip" of vegetation between the plant and evaporation ponds?

ANSWER 49

See Figure 2 for the exact location and orientation of the buffer zone with respect to the evaporation ponds. At the narrowest point the evaporation ponds are approximately 100m from the main plant.

QUESTION 50

What is proposed in the landscaping program?

ANSWER 50

There will be a detailed landscaping planning programme submitted to the EPA prior to construction. It will deal with aspects such as screening, decreasing water usage, amelioration of salinity and supplementing the riparian vegetation.

QUESTION 51

What does it mean when the PER states:

- *"..the potential will arise at small expense to encourage regeneration..."*
- *"..some planting..."*
- *"weed control activities compatible with the Company's general site maintenance programme".*

ANSWER 51

See Answer 50.

QUESTION 52

What basis is there for considering water fowl will only land on the large evaporation ponds and not on any other, the wildfowl will not remain on these ponds for extended periods or that these ponds will not pose a hazard to birds?

ANSWER 52

The one basin of concern, the acid effluent storage basin, will be covered with a protective netting to prevent birds from landing. The contents of the evaporation and iron oxide basins will not be hazardous to waterfowl. Based on the premise that the basins will provide no shelter or food for waterfowl it is anticipated that the birds will not spend extended periods of time on them.

QUESTION 53

What will happen if the birds land on the Acid Effluent storage basin with an effluent with a pH of 1.3?

ANSWER 53

The acid effluent basin will be covered with a protective netting. Thus the birds will not be able to land on the basins.

QUESTION 54

How will keeping records of incidents and supplying information to the EPA protect birds?

ANSWER 54

The concept of keeping record of the incidents of birds on the basins was not designed to protect the birds. Rather it was designed for the purpose of identifying problems and then being used to find solutions.

QUESTION 55

The PER does not mention the proximity or connection to the Lake Chandala Nature Reserve or the Ellen Brook Reserve and potential impact on the respective wildlife in these areas.

ANSWER 55

The Chandala Nature Reserve is located 2km north and upstream of the proposed plant. The impact of the plant on the wildlife of the reserve will be negligible. Between the reserve and the site there is a large buffer of tree and shrub growth that will act as a shield for both noise and light. With respect to impact on the water courses in the area the site is located downstream and thus there will be no impact.

There will be no discharge from the synthetic rutile plant into the Ellen Brook. Therefore no impact is expected anywhere downstream including the Ellen Brook Reserve.

QUESTION 56

What happens if important archaeological or ethrographic sites are found? Will they or will they not be considered in the plant design?

ANSWER 56

See Answer 32.

QUESTION 57

On what basis is it asserted that the TiO_2 project will not affect other properties nearby? What will happen if this is found incorrect through water table changes, leakage of process effluents, air emissions, noise.

ANSWER 57

In terms of air and noise emissions the assertion that other properties will not be affected is based on the premise that the plant will be operating within the EPA limits including the stringent requirements of the Victorian EPA. With respect to leakage of process effluents and water table changes, all the necessary precautions will be taken in terms of modelling prior to construction in the case of the basins. After which water table and careful design research for the monitoring will ensure that the design is in fact correct. Should any of the design of the above mentioned items not conform to standards they will be modified.

QUESTION 58

What does "no special planning requirements" imply?

ANSWER 58

Town planning is already in place and adequate residential areas are available in neighbouring towns.

QUESTION 59

What will the plant look like from the road and nearby residences?

ANSWER 59

The view from the Brand Highway will be limited by the landscaping. The landscaping will be designed to reduce the visibility of lights and the buildings thus reducing the plant's overall visual impact to nearby residences.

QUESTION 60

Will the trees be high enough to screen the plant?

ANSWER 60

The trees will not be high enough to screen the stacks but they will be able to greatly reduce the visual impact of the buildings.

QUESTION 61

At Narngulu the lights on the plant can be seen from 20 km away. Will this be the case at Muchea?

ANSWER 61

The Muchea site will be landscaped to reduce the visual impact of the plant. Therefore, it will not be like the plant at Narngulu.

QUESTION 62

The calculations for Delivery Vehicles/day need to be recalculated to indicate vehicle movements. What are the vehicle movements/day and how will this effect the percentage use of major roads?

ANSWER 62

The synthetic rutile plant will generate the following vehicle traffic:

Traffic	Vehicle Movement/Day
Coal	20.0
Sulphur	0.6
Lime	0.9
Sulphuric Acid	1.1
Ammonium Chloride	0.1
Sub Total	22.7
Staff	60.0
Total	82.7

The resulting increase in vehicle movements on Brand Highway due to the synthetic rutile plant will be 83 vehicles (3.9%). The combined effect of the dry process plant and the synthetic rutile plant will be an increased vehicle movement of 200 (9.6%). However, the increase in traffic travelling through Muchea will be less than this figure (about 150 vehicles/day or 7%) since heavy traffic associated with the dry process plant will all be travelling between the plant and the minesite north of Muchea.

QUESTION 63

What improvements will be made to facilitate entry and exit to the Brand Highway?

ANSWER 63

The Main Roads Department has been consulted on this matter and acceleration and deceleration lanes are to be built to the Main Road's specifications.

QUESTION 64

Will the movement of raw materials and product conform with the Dangerous Goods Regulations?

ANSWER 64

All applicable rules and regulations will be implemented in the transport of raw materials.

QUESTION 65

What are the risks and hazards to the environment associated with the transport of the proposed materials?

ANSWER 65

The only hazardous process material being transported is sulphuric acid. The safe transport of this material by road is a well established practice in WA.

QUESTION 66

Why is rail not used to transport more of the raw materials?

ANSWER 66

Rail transport will be used where economically feasible. At present, quantities to be tranpsorted are not sufficient to warrant rail transport.

QUESTION 67

What are the "stringent limits set by the Environmental Protection Authority"?

ANSWER 67

The air emission requirements set by the EPA are those defined by the Victorian Environmental Protection Act 1970. The standards of which have specific relevence to the synthetic rutile plant are listed in Appendix 4 of the PER and are listed again here as follows:

SO_2	1 hr average	$485ug/m^3$
dust	3 min average	$330ug/m^3$
H_2S	3 min average	$0.14ug/m^3$

QUESTION 68

What happens to the dispersion of plumes if the stack gases are of a lower temperature than expected?

ANSWER 68

The discharge plume will be little affected. The plume will be visible at a point closer to the top of the stack.

QUESTION 69

What happens if the afterburner breaks down?

ANSWER 69

The H_2S concentration will never reach a toxic level. If the breakdown is anticipated to extend beyond a few hours, the plant will commence a shutdown mode.

QUESTION 70

How will dust around the plant and stock piles be controlled?

ANSWER 70

A combination of landscaping, sweeping etc. will be used to keep dust to a minimum. For more details refer to Answer 22.

QUESTION 71

What effect will the SO_2 fallout have on the surrounding area?

ANSWER 71

There will be a negligible effect from the emissions of SO_2 as the plant will be operating within the limits set by the EPA.

QUESTION 72

This table does not mention particulates, will any such emissions occur?

ANSWER 72

Yes, there will be particulate emissions from the stacks. The emissions will be as follows:

Stack 1	$300mg/Nm^3$
Stack 2	$300mg/Nm^3$
Stack 3	$300mg/Nm^3$
Emergency Stack 1*	$450kg/hr_3$
Emergency Stack 2	$0mg/Nm^3$

* It is forecast that the emergency stack 1 will not be used more than five times a year when it will operate for less than one hour.

QUESTION 73

What are the likely worst case scenarios for air emissions and how often will these occur? What will be the environmental impacts of these emissions?

ANSWER 73

The worst case scenario with respect to air emissions occurs in stability Class A (see Appendix 4 in the PER). In the Muchea area this occurs about three per cent of the time and is most common in the summer. In this case all atmospheric emissions remain within the EPA limits, and have a negligible environmental impact.

QUESTION 74

Will emergency power be supplied to pollution control equipment?

ANSWER 74

Emergency power will be supplied to the pollution control equipment deemed necessary by the proponent in consultation with the EPA.

QUESTION 75

What research is proposed to be undertaken to investigate the suitability of various solid wastes as soil conditioners to ensure contaminants in the residue are not mobilised?

ANSWER 75

In conjunction with other producers of synthetic rutile, the proponent will support a 3 year research programme by the University of Western Australia to assess the suitability of solid wastes/soil conditioners. The study will:

i) Determine the physical and chemical properties of the solid waste produced by different plants;

ii) Assess the physical and chemical properties of the solid waste produced by different plants;

iii) Conduct pot and field trails with treated soils to examine the growth of a range of plant species, to examine the accumulation of trace metals in the plant tissues and to examine the effect of other additives upon the responses of the plants.

The proponent will also undertake a short term study at Murdoch University, commencing in February 1989, to obtain more immediate data on the growth of a few crop plant species on soils treated with solid wastes. This will consider the impact of a range of treatments on plant growth and accumulation of trace metals.

QUESTION 76

What techniques will be used to dispose of the solid wastes at the minesite? What is the possibility that groundwater at the minesite will be contaminated by residual ammonium chloride or radioactive residue?

ANSWER 76

The iron oxide waste will be sun dried in the evaporating pond, reclaimed as a moist solid and transported to the mine by road truck. The oxide will then be buried by spreading on top of the lower layers of overburden during mine rehabilitation. The oxide will contain about 30% of a 1% solution of ammonium chloride. This will be leached into the groundwater with no perceptable effect. The ammonia will disperse into the soil to be taken up by plants and the chloride ions will react with other substances to form harmless chlorides.

There are no radioactive residues in the waste streams from the synthetic rutile plant.

QUESTION 77

As indicated earlier, justification of the design of the various effluent dams is required to demonstrate that all worst case scenarios have been accounted for, particularly as the site is lowlying and prone to flooding.

ANSWER 77

The design concept has been established to the level necessary for this Environmental Report and for cost estimating only. Some criteria have been included in Answer 21. The ponds will be constructed with the liners above the water table and the level of the water table will be controlled by the perimeter drains. The site is not a flood plain as detailed in Answer 25.

QUESTION 78

Will fill be required for the dam walls? If so from where will this fill be obtained?

ANSWER 78

The detail design of the ponds has not yet commenced, and the location of suitable fill for construction awaits the results of the site soils investigation. Detailed design will be finalised during the first quarter of 1989.

QUESTION 79

There are other liners and thicknesses of liners available, on what basis does the PER claim that 1 mm HDPE is "the most secure, long lasting and expensive liner..."? What is the risk of failure over the 15-30 year life of the plant?

ANSWER 79

Recent pond design and construction exercises for a number of similar plants have concluded that a fully welded, high density polyethylene film is the most suitable liner. The thickness is dependent on the degree of exposure to ultra violet light and the probability of mechanical damage. In this instance it is intended to protect the liner with a layer of sand. This system has a history up to 10 years old. If mechanical damage and ultraviolet attack are excluded a buried liner probably has an indefinite life.

QUESTION 80

At what height will the liner be above the water table?

ANSWER 80

See Answer 72.

QUESTION 81

Various submissions have suggested that there are insufficient details about the leak monitoring system and an insufficient number of bores to successfully recover any leaked material. Please provide information on these above matters.

ANSWER 81

There will be one groundwater bore located upstream and three downstream of each pond, though this policy might be modified should the hydrological study prove it necessary. Any changes will be done in consultation with the EPA. The locations of the intercept bores are dependent on the results of the hydrological survey and thus have not been sited.

QUESTION 82

What parameters and how often will the proponent be monitoring in the Chandala Brook above and below the site? What will the proponent do if there is any variation in water quality? To whom will the proponent report?

ANSWER 82

The monitoring programme for Chandala Brook will consist of three stages. Firstly baseline data will be collected prior to commissioning of the plant. Then upon commissioning a regular sampling programme will be made in order to ensure the brook is not being contaminated. After which a regular monitoring, during periods of flow, will be maintained. The results will be reported to the EPA. The parameters to be tested will be pH, sulphate, chlorides and TDS.

QUESTION 83

What will the proponent do in the event of a dam liner or pipe failure?

ANSWER 83

In the case of leaking the proponent will contain and recover the spilled material while repairing the damaged equipment.

QUESTION 84

What will be the effect on the groundwater if a leak occurs in the iron oxide basin particularly with the residual levels of NH_3-N, or from the acid effluent storage basin.

ANSWER 84

There will be no impact on the groundwater from the iron oxide basin as the level of NH_3-N will be minor. Any leaks from the acid effluent basin will be isolated within the property boundary.

QUESTION 85

Because of the low lying nature of the site has any other method of septic waste disposal been considered which would minimise microbial contamination of the groundwater?

ANSWER 85

Considering the nutrient loading produced by the plant septic waste disposal was found to be the best method of disposal. Self contained units were considered but dismissed for being uneconomical. The subject has been discussed with the local authority.

QUESTION 86

How stable are the soils below the dams, is there any possibility of subsidence occurring?

ANSWER 86

A detailed sub surface soils investigation has not yet been completed. The soils investigation will confirm the foundation conditions. If poor soils were encountered the dams would be relocated or redesigned.

QUESTION 87

Appendix 3 indicates a maximum noise level (under worst case conditions?) of 52dBA. How will attenuation be achieved?

ANSWER 87

The individual items of equipment will be attenuated by means such as acoustic enclosure, insulation etc.

QUESTION 88

What standards other than AS1055-1984 will be used to determine "acceptable" noise levels at the closest residence during plant operation?

ANSWER 88

AS1055-1984 is a standard series used as a guideline for measurement of existing background noise levels and the acceptability of introduced noise. These guidelines are subject to any special conditions the EPA may deem necessary to place on a particular site or area. Liaison with the EPA was done prior to the noise study to determine if there were any special provisions. In the case of the synthetic rutile plant no special provisions were required.

QUESTION 89

The PER discusses noise levels for construction and plant operation, please provide more details of noise from machinery operating on the site once the plant is operational eg a dragline or scraper cleaning out the dams.

ANSWER 89

Mobile machinery operating on site after construction will be minimal. What little there will be will be restricted to daylight hours.

QUESTION 90

How will it be determined if new plant equipment will need to be used on site during construction?

ANSWER 90

As mentioned in Section 7.2.3 of the PER plant noise will be monitored during the construction phase. The results from this will determine if it is necessary to attenuate the construction machinery.

QUESTION 91

Appendix 5 provides information about plant radiation management and monitoring for the dry processing plant. Are the monitoring proposals in this Appendix applicable to the synthetic rutile plant?

ANSWER 91

The synthetic rutile plant has no radioactive waste. However, as the dry processing and synthetic rutile plant occupy the same site, monitoring will include the synthetic rutile plant.

The detailed radiation monitoring programme will be determined in consultation with the appropriate regulatory authority prior to operations commencing.

The sample radiation programme given in Table 1, Appendix 5 of the PER, describes the type and frequency of monitoring anticipated in so far as other than designated employees are concerned. The programme for environmental locations outside the site boundaries will be common to both the dry processing and synthetic rutile plant.

Work on determining pre-operational background radiation levels at the site has commenced.

QUESTION 92

Are there any parts of the plant eg pipe work or filters which may, over time, accumulate radioactive contaminants? How will this plant be disposed of in the future?

ANSWER 92

Within the synthetic rutile plant there will be no areas where radioactive contaminants will accumulate. As such, no special procedure of disposal is required.

QUESTION 93

Will pressure and flow indicators register a break in an open ended pipeline?

ANSWER 93

Visual observation will be used to monitor breaks in an open ended pipe. Pressure and flow indications are not feasible.

QUESTION 94

When will detailed design of dam construction be submitted to the EPA?

ANSWER 94

Detailed design of the dam construction will be submitted to the EPA prior to construction.

QUESTION 95

Quarterly monitoring may not give an indication if H_2S or SO_2 are causing nuisance. This will rely on the public complaint if detection is to occur. More comprehensive details of a monitoring program and reporting procedures are required.

ANSWER 95

Upon commissioning of the plant an intensive monitoring programme will insure that all air emissions are within the EPA limits, after which monitoring on a quarterly basis will be done. In addition to the quarterly monitoring, standard operating procedures will be introduced in which operating staff will be trained to detect, report and take remedial action if nuisance emissions such as H_2s and SO_2 are identified.

QUESTION 96

What are the results of the pre-operational monitoring programme?

ANSWER 96

The pre-operational air quality monitoring programme has just recently commenced.

QUESTION 97

Please provide further details of the proposed monitoring and reporting provisions.

ANSWER 97

The results from all the monitoring programmes will be reported to the EPA for their assessment. Any modification of the following programmes will be made in consultation with the EPA.

Air Emissions

There will be three stages of monitoring. An initial pre-operation testing programme will be set up to establish baseline data. Then, after start up a monthly monitoring programme will be conducted to ensure EPA limits are met. After 12 months of operations a regular quarterly monitor programme will be maintained. The parameters that will be monitored are SO_2, H_2S and dust.

Noise

Baseline levels have already been taken. Monitoring will be undertaken during construction and commissioning to ensure that these baseline levels are not exceeded by the allowable 5 dBA. Thereafter monitoring will be done on a quarterly basis.

Water

Monitoring of ground water will be done on a monthly basis during the pre-operational stage and the first two years of operations. Thereafter the groundwater will be monitored on a quarterly basis. The parameters that will be monitored are sulphates, pH, TDS and chlorides. Refer to the response to Question 81 for bore locations. In addition Chandala Brook will be monitored above and below the site during periods of flow.

Radiation

There are no radioactive wastes in the synthetic rutile plant. Any monitoring done is due to the fact that the synthetic rutile plant occupies the same site as the dry processing plant.

Radiation monitoring is outlined in Section 7.2.5. Radiation Monitoring.

The principles applied to the dry separation plant will be followed in the synthetic rutile plant and be subject to review and agreement with the Department of Mines and other relevant authorities.

An initial programme of quarterly gamma ray checks at selected locations in the plant will be conducted. Monthly sampling of airborne dust in the vicinity of the magnetic separators will also be conducted.

The results will be reviewed with the Department of Mines after six months' operation to determine ongoing monitoring levels.

Sampling of environmental radiation outside the plant boundaries will be incorporated in the programme already in place for the dry process plant.

Monthly sampling of groundwater quality adjacent to storage dams will also be carried out to check for trends in radioactivity levels.

QUESTION 98

The Commitments need to make quantifiable statements which bind the proponent to a certain specific course of action. Generalised statements such as "monitoring of stream flow and water quality..." do not provide sufficient information about which to judge the proponent's commitment to environmental management or indicate well thought out contingencies in the event of some emergency or plant operation not meeting expected performance standards.

ANSWER 98

Further detail of the monitoring programmes and remedial actions have been given in Answers 82, 91, 95 and 97.

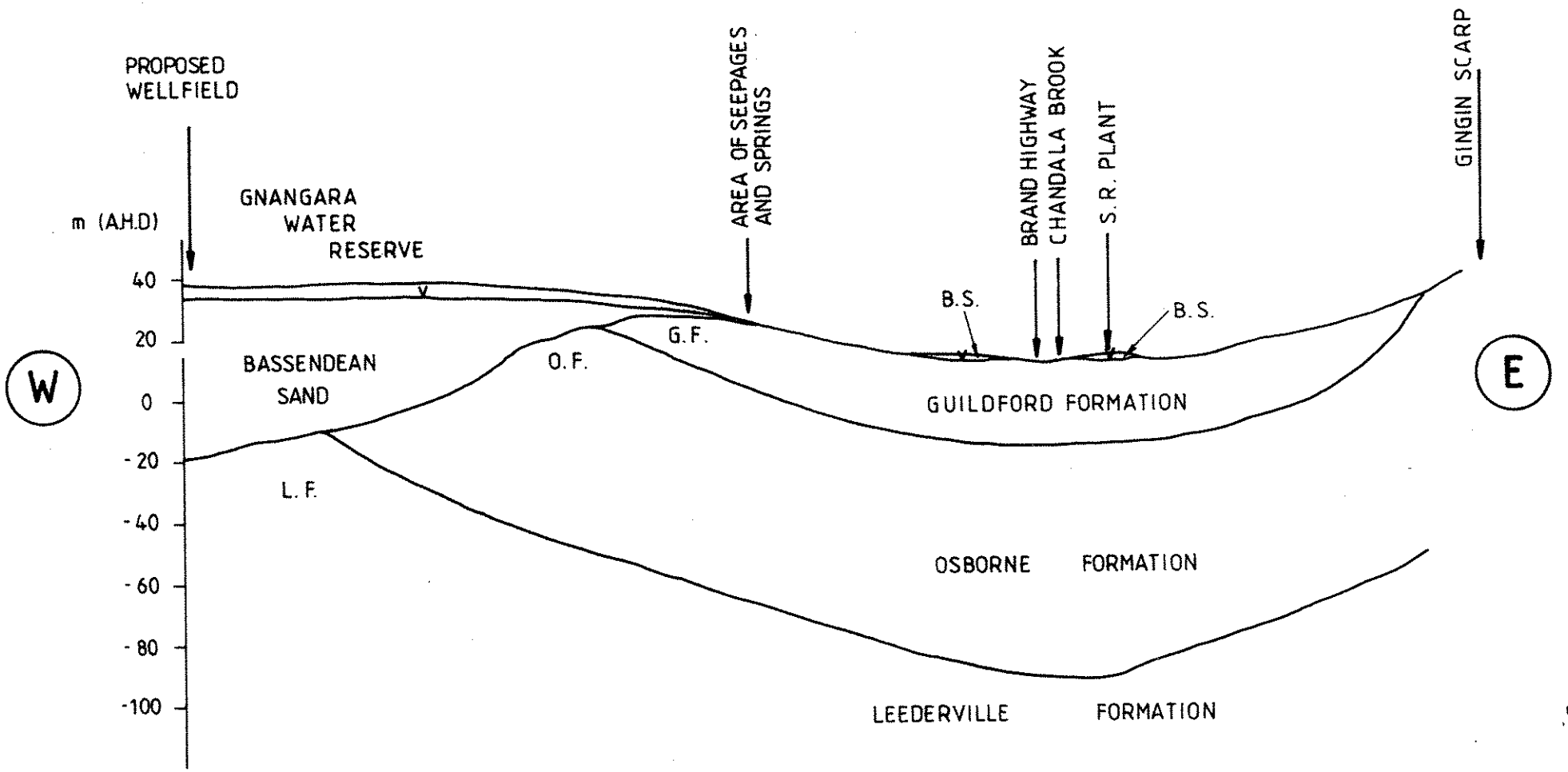
OTHER COMMENTS

QUESTION 99

The report is particularly deficient in providing information on the proposed decommissioning of the site and end use of the area. This should be addressed.

ANSWER 99

The proponent will submit plans to the EPA of decommissioning the plant and surrounds 6 months prior to decommissioning. These plans will be drawn up in consultation with the EPA.



KEY: B.S. = BASSENDEAN SAND
G.F. = GUILDFORD FORMATION
O.F. = OSBORNE FORMATION
L.F. = LEEDERVILLE FORMATION
⊻ = WATER TABLE

km
0 1
HORIZONTAL SCALE

NOTE: FOR LOCATION OF WELLFIELD AREA SEE FIGURE 1

HYDROGEOLOGICAL SECTION E-W THROUGH SITE AND WELLFIELD AREA

FIGURE 3

Appendix 2

Report by Cooljarloo Joint Venture on Water Related Issues

KMM AUSTRALIA INTERNATIONAL PTY LTD

1274/16

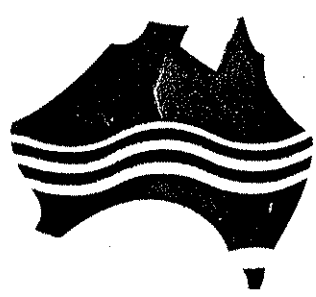
NOVEMBER 1988

HYDRAULIC AND HYDROLOGICAL ASPECTS OF THE SITE AND OPERATION AT THE SYNTHETIC RUTILE PLANT MUCHEA

ENVIRONMENTAL MONITORING

AND MANAGEMENT PROGRAMME

AUSTRALIAN
GROUNDWATER
CONSULTANTS
PTY LIMITED



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EXECUTIVE SUMMARY

Introduction

A detailed environmental study of the hydrological and hydraulic conditions of the site and plant operations at Muchea has been carried out.

The basis of the report is the definition of all environmental water and plant process flows, such that potential impacts on the environment could be assessed.

This is to result in the specification of detailed monitoring and management programmes to preclude any adverse impacts of the operations on local and regional water quality. These programmes will be included in an environmental management plan.

Description of Local Hydrology

The local hydrology in terms of dominant flow processes has been described from available data and recently implemented monitoring sites.

The site hydrology is affected by its agricultural land use and by flow contribution from the railway line, highway drainage and agricultural properties to the west of the site.

The monitoring currently being undertaken will serve as baseline data for when plant construction and operation commences.

Hydraulic Design of the Operations

Components of plant water usage are listed as -

- Process Water Supply
- Plant Process Streams
- Effluent Discharge

Abstraction from the plant water supply borefield will have no significant effect on the local hydrology or environment.

Process water is mostly discharged by evaporation with an amount returned to the minesite with tailings. Design of the evaporation and iron oxide ponds has been made to ensure that no discharge to surface water or groundwater will occur under normal operating procedures.

Assessment of Impacts

Impacts of the operations that may result in changes to environmental water quality are related to discharge or leakages from the wastewater evaporation ponds.

All the process streams within the plant are to be fully contained, should a plant failure occur.

Examination of a worst case pond failure scenario (that which may occur following sabotage) has shown that elevated levels of only two contaminants, copper and chromium, may occur. Further investigation showed that the levels of contamination of these metals would be lower than those found in many existing surface waters on the Southern Coastal Plain.

Contamination of local shallow groundwater by pond leakage is expected to be highly unlikely. If it did, groundwater flow velocities indicate it may take about 3 years for any polluted groundwater to reach Chandala Brook.

Description of the Monitoring Programme

A monitoring programme for the site hydrology has been specified -

- Routine sampling of surface water diversion.
- Continuous inflow and outflow monitoring and routine sampling of Chandala Brook.
- Routine shallow groundwater monitoring and sampling.

The sampling programme will be aimed at quantifying any changes to surface water yield and quality following commencement of the operations.

The regular analysis of water quality data will provide an early warning should leakage occur.

Definition of the Management Programme

The management programme has been specified in order to -

- Design the operations in such a way as to preclude any discharge of the process streams into the environment.
- Define management alternatives to recover any leakages caused by accidental spills.

The management programme will also include procedures for gross contamination caused by spills such as road tanker or train accidents. These will be defined in accordance with the requirements of relevant authorities.

1 INTRODUCTION

1.1 Background

Hydraulic and hydrological documentation has been compiled in order to provide information to the Environmental Protection Authority (EPA) pertaining to the construction and operation of the proposed synthetic rutile plant at Muchea.

The EPA has been briefed about the likely environmental aspects of the project and the Proponent's time frame for plant construction and operation.

Areas of concern which have been identified by the EPA, and form the basis of this report are -

- The water supply, usage and disposal.
- Description of the plant process streams and water management.
- Commitments to monitoring and management programmes.

A preliminary Table of Contents of this report was provided to the EPA in early November 1988. This provided the basis on which the report contents were formulated.

1.2 Objectives of this Report

In order for the EPA to make a detailed assessment of the potential water related impacts of the project, a detailed study has been carried out of the site hydrology, water and contaminant flow streams in the plant, and assessment of potential contaminant impacts.

This has resulted in the specification and implementation of site monitoring programmes, and the definition of management programmes to preclude any probable adverse environmental impacts of the operations.

Water related issues which were addressed are listed as follows -

- Water abstraction impacts (from the nearby borefield).
- Environmental impacts along the supply pipeline route.
- Plant usage of water detailing the process streams and contamination sources.
- Water disposal by evaporation and settling ponds.
- Existing site hydrology and hydrochemistry.

Following discussion with personnel from the EPA and the Water Authority of Western Australia, management programmes to which the proponent has made commitments were specified.

2 DESCRIPTION OF LOCAL HYDROLOGY

2.1 Site Description

The proposed site at Muchea has an area of 340 ha and comprises the whole of Lot M1261 of Swan Location 1352. The site is bounded to the west by the railway line and the Brand Highway, to the east by a closed public road, and to the north and south by agricultural land. The southern boundary is 4 km from the Muchea townsite (Figure 1).

The site is 80% cleared of natural vegetation and developed for grazing.

2.1.1 Soils and Landform

The site is situated on a WSW facing slope of low relief, with a gradient of about 0.04. Maximum elevation is approximately 57 m AHD at the north-eastern corner of the property. The Chandala Brook enters the property at the north-western corner, flows in a southerly direction and leaves the property in the south-western corner. Three tributaries, two from the west and one from the east, enter the Chandala Brook within the boundaries of the property. Chandala Brook is a tributary of Ellen Brook which feeds into the Swan River.

The soils of the Muchea site are part of the Pinjarra Plain system which is a tract of alluvial deposits extending from Gingin in the north to south of Pinjarra. Three soil units designated S_{10}, S_{11} and Mgs_1 (Western Australian Department of Mines, 1984) have been found on site. Figure 2 shows the distribution of these soil units on the site.

The S_{10} unit consists of 0.25 - 0.6 m of fine to medium quartz sands over either a limestone base or a brown clay/silt horizon which is frequently cemented, commonly known as "coffee rock".

The S_{11} unit consists of deep, medium grained quartz and feldspar sands. Colour varies from grey to white with depth, reflecting a decrease in organic matter.

The Mgs_1 unit consists of 0.2-0.3 m of silty sand or clayey sand topsoil over 1 - 1.2 m of clayey sand. Cemented clayey sand (coffee rock) occurs at 1 - 1.2 m.

In October-November 1988, test pits were excavated on the site to investigate the shallow soil conditions. Locations of the test pits are shown on the soil map (Figure 2).

The soil profiles encountered were basically the same in each hole. Typical soil profiles are given in Table 1. The major difference between profiles was the presence and nature of, or depth to the cemented horizon underlying the surficial sands. The cemented horizon varied in description from being 'weakly cemented' to 'strongly cemented which refused a KATO 1220 Excavator'.

TABLE 1

TYPICAL SOIL PROFILES

Depth (m)	**Soil Description**
HOLE MH5	
0 - 0.1	Dark grey, organic, sandy topsoil.
0.10 - 0.7	SAND; light grey, medium grained, quartzose, moist to wet, loose.
0.7 - 1.1	SAND; light grey, strongly cemented.
1.1 - 2.8	White and light grey sand, medium to coarse grained, wet.
2.8 - 5	SAND; dark brown, grey medium grained, some clay in places, wet.
5^+	SAND; grey, medium grained, wet.
WATER TABLE:	at approx 1 m.

TABLE 1 (Cont'd)

Depth (m)	**Soil Description**
HOLE MH8	
0 - 0.15	Dark grey, organic, sandy topsoil.
0.15 - 2.8	SAND; white and light grey, medium grained, quartzose, moist to wet, very loose.
2.8 - 3	SAND; dark brown, moderately cemented "coffee rock"
3 - 5	SAND; grey brown, medium grained, wet, loose
WATER TABLE:	at approximately 1.2 m.

A full description of the soil profiles is given in Appendix I.

2.1.2 Climate

The Region receives an average rainfall of 750 mm/year and has a pan evaporation rate of 2 040 mm/year. Table 2 lists monthly rainfall data for the Muchea townsite and evaporation data from the Bureau of Meteorology Upper Swan Research Station, the locations closest to the property for which long term weather records are available.

TABLE 2

MONTHLY RAINFALL AND PAN EVAPORATION

Month	Rainfall (mm) (Muchea Townsite)	Pan Evaporation (mm) (Upper Swan Research Station)
Jan	21	338
Feb	17	266
Mar	19	239
Apr	50	144
May	108	99
Jun	141	75
Jul	128	74
Aug	97	81
Sep	70	102
Oct	54	158
Nov	33	201
Dec	11	262
YEAR	**749**	**2 040**

2.1.3 Vegetation

The site is about 80% cleared, the remaining 20% being a Banksia dominated low woodland with scattered taller trees of Marri, *Eucalyptus calophylla* and Jarrah, *Eucalyptus marginata*. The Banksia woodland comprise *Banksia attenuata*; *Banksia ilicifolia*, and *Banksia menziesii* associating with *Nuytsia floribunda*. The Flooded Gum, *Eucalyptus rudis* and Paperbark, *Melaleuca preissiana* are common along Chandala Brook.

Surviving understorey species include, *Acacia cyanophylla*, *Banksia attenuata*, *Banksia grandis*, *Dryandra sessilis*, *Grevillea vestita*, *Jacksonia sterbergiana*, *Nuytsia floribunda*, *Xanthorrhoea preissii*, *Petrophile linearis* and *Anigozanthos manglesii*.

There is a large infestation of Arum lillies, *Zantedeschia aethiopica*, along the banks of Chandala Brook and the wetter areas on the site are identifiable by dense clumps of these plants.

The site has been highly disturbed, the residual native vegetation being represented in many areas elsewhere on the Coastal Plain in more pristine environments.

2.2 Surface Water Hydrology

The plant site is situated on generally flat, low lying ground in the upper reaches of the Ellen Brook catchment. The main water course on the property is Chandala Brook running north-south with two minor tributaries flowing from the west, and one from the east draining the cleared area of the property.

The silts of the S_{10} and Mgs_1 soil units are relatively poorly drained which, together with the low gradient of the land, results in the area being subjected to seasonal water logging. Water movement to the Chandala Brook or its tributaries occurs largely through constructed drains. Groundwater flow occurs through perched water in the S_{10} and S_{11} soil units, which have relatively sandy and permeable surface horizons and surface flow over the Mgs_1 soil units. Deep percolation of water received as rainfall and subsequent flow to surface water courses or underground aquifers would occur in all soil types.

The stream bed for Chandala Brook mainly consists of sand, with some coffee rock outcrops occurring.

Water flow in Chandala Brook, in September 1988, was estimated to be 0.5 m^3/s at the southern boundary of the property. Flows would be subject to wide variation according to rainfall and would be considerably less during summer months.

Water samples taken from four sites on Chandala Brook (Figure 2) within the property were analysed for water quality (Table 3).

TABLE 3

TYPICAL CHANDALA BROOK
WATER QUALITY ANALYSIS

	Site 1	**Site 2**	**Site 3**	**Site 4**
pH	6.4	6.5	6.2	6.55
EC (µS/cm)	1 100	1 160	1 170	1 210
TDS (grav)	770	790	660	750
Na	170	175	160	175
K	4.5	4.0	5.5	4.5
Mg	22.5	23.5	26.0	25.5
Cl	300	315	320	330
SO_4	25	25	25	30
NO_3	<0.05	<0.05	<0.05	<0.05
Ca	11.5	11.5	6.0	10.5
Mn	<0.05	-	-	-
Suspended Solids	30	70	75	55

All values in mg/L except pH and EC.

Interpretation in any quality variations on the site will be made following longer data collection period.

2.3 Hydrogeology

Drilling logs from a deep bore at the proposed plant site reveal that the site is underlain by superficial sands (0 to 10 m), silty sandy deposits known as the Guildford Formation (10 to 50 m), then the often glauconitic sandy shale and shales of the Osborne Formation (40 to 96 m), and the underlying Leederville Formation.

The Leederville Formation continues beyond the 250 m depth of drilling. The deposits penetrated were shales, silty clays and fine to coarse sands. An intersection of sands between 132 and 150 m was selected for the well-screens in the completed production bore. This Leederville Formation aquifer is isolated from the superficial deposits by its depth of occurrence and the shales in the sequence between 50 and 120 m depth. The aquifer is confined with a potentiometric surface at about ground level, and preliminary results indicate the groundwater to be of potable quality.

The Superficial Formations at the site are sandy in the northern part near the ground surface and commonly become more silty within the topmost few metres. The water table generally occurs (November 1988) at 0.8 to 1.5 m below ground level. There is often an associated horizon of weakly to strongly cemented sand (coffee rock) 0.2 to 1.0 m thick. Estimates of permeability of these surficial deposits range from 0.75 m/d in the southern area to 1.7 m/d in the middle of the site.

The water table mapping indicates that the direction of groundwater flow in the surficial levels is towards the Chandala Brook in a south-westwards direction.

2.4 Existing Site Water Balance

Site water balance components under the existing land use are being determined in order to predict any changes that may occur following plant construction and operation.

Water flow components being quantified are listed as follows -

INFLOWS

- Rainfall (recharge)
- Stream inflow (from upstream Chandala Brook and surface water tributaries)
- Groundwater Inflow

OUTFLOWS

- Evaporation
- Stream outflow (in Chandala Brook) exiting the property.
- Groundwater outflow.

Agricultural pursuits involving the clearing of natural (higher water using) vegetation, results in lowered transpiration and increased net groundwater recharge. Extensive surface ponding of water occurs at the proposed plant site following rainfall events. Drains are currently used at the site to direct surface water to natural stream and partially alleviate water logging problems. Build-up in water levels due to increased recharge may lead to increased groundwater flow contribution to surface water runoff and stream flow.

3 HYDRAULIC DESIGN ASPECTS OF THE OPERATIONS

3.1 Water Abstraction and Plant Supply

3.1.1 The Process Water Supply

A process water supply requirement for the plant site has been estimated at 2 700 m^3/d, although this quantity will vary according to the input of water from the stormwater pond. The supply is to be obtained from a borefield installed in the superficial formations to the west of the plant site (Figure 3). The hydrological conditions of the borefield area have been examined in studies undertaken by state authorities in assessment of water resources of the Gnangara mound.

It is expected that two production bores will be required to satisfy the demand. These bores will be spaced approximately 1 km apart in a north-south line in order to minimise drawdown interaction and to intercept the eastwards flow of groundwater from Gnangara mound. Currently, an exploration licence is being obtained from the Water Authority for investigative drilling. It is not anticipated that there will be any difficulties in obtaining the required volumes of water from this aquifer.

A pipeline will be built from the borefield along the road reserve to the plant site. Power lines will traverse the same route from the Brand Highway. Environmental studies have been recently undertaken in and adjacent to the proposed borefield, and along the pipeline route. These are described in the following subsections.

3.1.2 Infrastructure for the Borefield

The borefield will be serviced by a power line from the Brand Highway, along the pipeline route linking the plant site. Biological surveys were undertaken in the area of the proposed route as part of the borefield assessment.

3.1.3 Biological Survey

In November 1988, a botanical survey of the borefield area and surrounds, and the pipeline route was undertaken, a full report of the study being presented in Appendix II. At the same time, a fauna study of the same area was carried out. The fauna report is presented in Appendix III.

The borefield site is proposed to be located on vacant crown land which is mostly uncleared Banksia woodland. A survey carried out in the area found no evidence of the presence of the fungus dieback disease, *Phytopthora cinnamomi*, however the area is expected to be highly susceptible to the fungus. The private property adjacent to the vacant crown land, on which the pipeline will be constructed, has been cleared for pasture and it is likely that these areas may contain dieback.

Results from the botanical study indicated that no rare or endangered species were observed or are expected to occur in the area. The vegetation classes are well represented in many other areas and in any case are unlikely to be affected to any significant amount by the borefield operation.

The Fauna Survey carried out in mid-November found that three "rare and endangered species" may be found in the vicinity of the proposed borefield. They include the Peregrine Falcon, *Falco Peregrinus*, the Chuditch *Dasyurus geoffroii* and the Black-Striped Snake, *Vermicella calonotus.*

The Peregrine Falcon is a highly mobile species and therefore most unlikely to be affected by the project. The Chuditch, or Native Cat, is opportunistic and utilises a large area of land. It will feed on prey species associated with the wetland areas but is unlikely to be affected by the borefield because of its large territory range. The sandy environment of the borefield site is a probable location for the Black-Striped Snake, which commonly burrows and is rarely seen. Because of its burrowing and feeding habits, the borefield is not seen to have any measurable effect on the local populations.

In terms of faunal species expected and habitats available, the site is well represented in many other areas of the northern coastal plain.

3.2 Process Plant Water Management

3.2.1 Process Streams

Process waste water streams will be contained so that no contaminated waters can be discharged off-site. Three waste water streams can be identified:

1) Acidic waste generated in the acid leaching plant. Waste flows include spent process acids, spillage and plant washdown water. The liquids will be pumped to evaporation ponds after neutralisation.

2) Process liquor stream. This is a solution of ammonium chloride containing fine iron oxide. Waste flows will also include spillage and plant washdown water. The iron oxides will settle out in the iron oxide ponds while the liquids are recycled to an aeration treatment process.

3) Washdown water from dry areas of the plant such as the separation and kiln-cooler facilities will be collected and recycled to the waste gas evaporative cooler.

A schematic of process flow and rates is shown on Figure 4, while Figure 5 shows the plant layout at the site.

A total of 54 m^3/hr of bore water is evaporated in kiln cooler service, and in temperature control of the exit gas in the evaporative cooler. It is estimated that 2 m^3/hr of fresh water will be utilised for washdown in the kiln section for dust removal. Washdown water will be collected in a sump and pumped back into the wet well of the evaporative cooler. This flow of 2 m^3/hr will not be continuous and will be utilised as needed for events such as dumping solids from the electrostatic precipitator, cleaning up process waste gas line and for washdown of solids spills in the area. An additional 2 m^3/hr of bore water has been estimated for wetting of dusting materials to be returned to the mine site.

All storage tanks and process vessels in the aeration section will be constructed on a concrete apron. This will be bunded to contain any discharge from a catastrophic vessel failure. In addition, it is estimated that 2 m^3/hr of washdown water will be used for housekeeping purposes. Spills and washdown will drain to a concrete sump. The process liquor in the aeration and hydro-cycloning circuits are the same and the chemical analysis is shown in Table 4. Process liquor spills or contaminated washdown water will be pumped to a surge tank and thence to either the process liquor tank or the iron oxide ponds.

The hydro-cycloning circuit will be constructed on a concrete apron which is fully bunded to accept line rupture in the circuit. The flow from this area will be directed to the aeration area collection sump and recovered into the process, as would spills collected in the aeration system. The spill collection sump pump will have a minimum capacity of 104 m^3/hr. The flow of liquid leaving the hydro-cloning circuit going to the iron oxide pond is estimated to be 98 m^3/hr. The details of the iron oxide pond construction are discussed in Section 3.2.2.

Process liquid in the iron oxide pond is recovered and returned back to the process liquid storage tank. The estimated flow recovery from the iron oxide pond is 97 m^3/hr.

The process flow piping both to the iron oxide ponds and the evaporation pond will be polyethylene pipe laid at ground level.

The acid leaching and washing area will also be constructed upon a concrete apron which is fully bunded to contain any discharge from failure of the process vessels. Any spillage in this area will be directed to a concrete sump with a pump. The concrete apron and sump for the acid leaching area is completely separated from the aeration and hydro-cycloning areas. The liquid may either be directed through the neutralisation system to the evaporative basins or back to the process after the source of the spill has been remedied. The sulphuric acid storage tank will also be fully bunded to contain the entire contents of the vessel should failure occur.

During normal operation, the flow from the acid leaching and washing system of 14 m^3/hr will be directed into a surge tank. The liquor from this tank will be mixed with about 2 m^3/hr of lime slurry and discharged to the evaporation ponds following neutralisation. The composition of the neutralised slurry is shown in Table 5.

The volume of each evaporating pond will be 150 000 m^3. Construction details of the evaporation ponds are given in Section 3.2.2.

Stormwater runoff will be directed to a stormwater runoff basin. Liquid in this basin will be a source of water for the process and should replace a portion of the bore water during winter months. The capacity of the stormwater runoff basin will be designed to cater for a 1:100 year rainfall return period of a three hour duration. Should the stormwater basin become over-filled during periods of heavy rainfall, the discharge will flow into Chandala Brook. The chemistry of this water will be that of normal rain water.

3.2.2 Pond Construction

The iron oxide and neutralised effluent evaporation ponds will be constructed to similar designs. They will be lined with a 1.0 mm thick high density polyethylene (HDPE) sheet and provided with underfloor leakage collection and a protective layer of sand.

The iron oxide ponds will be constructed on an area that is above the winter water table. Earthworks will use local materials in a cut and fill process. A network of perforated drainage pipes will be installed underneath the liner and bedded in coarse sand to collect any process liquor leakage. Leakage liquor will gravitate to a sump and be pumped back into the process liquor circuit. The liner will be protected by a layer of used car tyres and a bed of sand. These two features will provide protection when earth moving machinery is used to recover the settled iron oxide for return to the mine.

Two iron oxide ponds will be constructed initially with plans for a further pond to be constructed if deemed necessary. Each pond will have sufficient capacity for the design quantity of settled solids and a working volume of liquid. The design freeboard will be sufficient to cope with rainfall from the specified maximum storm event, plus wind stress. In addition, each set of ponds will be linked so that a full pond can overflow into a standby pond. Operating procedures will ensure that a standby pond is always available.

The neutralised effluent evaporation ponds will also be constructed above the winter water table. In addition, cut-off drains will be constructed to control ground water such that the level is always below the pond liner. The ponds will be constructed using both local materials and imported fill. Pond and drain levels will be decided after evaluation of soil permeabilities, ground water levels and other construction requirements. A network of collector drainage pipes will be installed underneath the liner and bedded in coarse sand to collect any leakage. The collected leakage will gravitate to a sump and be pumped back into the evaporation pond.

It is intended to recover the neutralised, settled solids and return them to the mine. Each evaporation pond will be constructed with a small decantation (settling) pond in one corner. This pond will be about 7% of the total area, and it is anticipated that it will collect 96% of the solids precipitated. The decantation ponds will be drained in sequence and the solids recovered and returned to the mine. The liner in each decantation pond will be protected by a layer of used car tyres on a bed of sand, as for the iron oxide pond. The liner in the evaporation pond will also be protected by a layer of sand. This will allow the gypsum precipitate to be removed as required.

A number of ponds will be constructed, arranged for sequential service so that one can be dewatered for solids recovery. Pond area will always be available for the evaporation of effluent. Each pond will have sufficient capacity for the design quantity of settled solids and a working volume of liquid. Again, the design freeboard will be sufficient to cope with the rainfall from the design event, plus wind stress. In addition, the set of ponds will be linked so that a full pond can overflow into a standby pond. Operating procedures will ensure that a standby pond is always available.

3.2.3 Potential Contaminants

The spent acid process liquor from the acid leach section has a pH of 1.3 with dominant ions being iron, sulphate and manganese. This liquor is neutralised with lime within the confines of the process plant.

Concentration of pollutants in the liquor in the evaporation pond following neutralisation is considerably reduced. The liquor is alkaline (pH 9-10) with calcium and sulphate being the dominant ions. Total dissolved solids have been estimated to be about 2 400 mg/L. Free (ionic) manganese is reduced in concentration to about 0.010 mg/L.

Full discussion of the impacts of these potential pollution sources is given in Section 4.

3.3 Evaporation Pond Design Basis

3.3.1 Environmental Flows

The process of rainfall and evaporation result in water flows into and out of the ponds. The average yearly deficit of water is 1 290 mm, indicating that an evaporation pond is practical in this environment.

3.3.2 Evaporation

The evaporation data reported in Section 2.1 were gathered using a Class A pan evaporimeter. In the calculation of the expected evaporation from the ponds it was necessary to correct this data for the salinity of the pond solutions, the greater surface area and the effect of the bird cage fitted to the evaporimeter. A conservative factor of 0.8 was used in the mass balance, taking into account these three factors.

3.3.3 Rainfall

In addition to catering for the average seasonal rainfall, the design is based on a freeboard of 300 mm plus 200 mm allowance for wind stress. The freeboard was calculated to allow for the additional rainfall from a 6 hour Probable Maximum Precipitation event in accordance with the Bureau of Meteorology Bulletin 51 (1984).

These criteria were compared with historic rainfall data provided by the Bureau of Meteorology for the Perth Observatory. The wettest ten months on record, starting in July, resulted in a surplus of 310 mm above the average rainfall. This figure has significance in that the proposed duty cycle of the pond is ten months, starting from 1 July. Thus it can be seen that a seasonally very wet winter has a similar storage requirement as the six hour event.

3.3.4 Design Cycle

The area allowed for evaporation ponds is 13 ha, divided into two ponds, nominally 3 m deep. Provision has been made for two more ponds to be constructed as required. The operating cycle consists of a period of duty, when the pond receives all of the plant effluent, followed by a period of evaporation, before the next cycle commences.

TABLE 4

CHEMICAL COMPOSITION OF
IRON OXIDE SLURRY AND PROCESS LIQUOR

Process Slurry Analysis All values in mg/L except pH	
Parameter	
pH	6.8
TDS	25540
Na	44.5
K	43.5
Cl	10760
HCO_3	48.8
SO_4	51.4
NO_3	0.05
As	0.005
Cd	0.005
Pb	0.05
Zn	0.05
Cu	0.05
Co	0.15
Ba	1.5
Cr	0.05
V	0.25
Ni	0.15
P (total)	0.05
Ti	0.02
(NH_3	5 000)
Solids	10%

Solids Analysis (% By Weight)	
Parameter	
Fe_3O_4	93.7
Al_2O_3	0.14
As_2O_3	0.0060
BaO	0.03
CaO	0.1
CoO	0.004
Cr_2O_3	0.0085
CuO	0.0016
MgO	0.017
MnO_2	1.9
MoO_3	0.38
Na_2O	<0.14
NiO	0.0072
PbO	0.0086
SiO_2	<0.0002
TiO_2	1.9
V_2O_5	0.0063
ZnO	0.0068
ZrO_2	0.1